

NATIONAL SCIENCE FOUNDATION
1996
ENGINEERING SENIOR DESIGN
PROJECTS TO AID PERSONS WITH
DISABILITIES



Edited By
John D. Enderle
Brooke Hollowell

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CONTRIBUTING AUTHORS

Richard Culver, Mechanical Engineering,
The Watson School, SUNY Binghamton, Binghamton,
NY 13902-6000

John Enderle, Electrical & Systems Engineering, Uni-
versity of Connecticut, Storrs, CT 06269

Marvin G. Fifield, Mechanical & Aerospace Engineer-
ing, Utah State University, Logan, Utah 84322-4130

Bertram N. Ezenwa, Department of Mechanical Engi-
neering, School of Medicine, Department of Physical
Medicine and Rehabilitation, Wayne State University
261 Mack Blvd Detroit MI 48201

Jerome A. Gilbert, Agricultural and Biological Engi-
neering, Mississippi State University, Mississippi
State, Mississippi 39762-5465

Daniel W. Haines, Dept. of Mechanical Engineering,
Manhattan College, 4513 Manhattan College Park-
way, Bronx, NY 10471

Brooke Hallowell, School of Hearing and Speech Sci-
ences, Lindley Hall 208, Ohio University, Athens, OH
45701

Mohamed Samir Hefzy, Department of Mechanical En-
gineering, University Of Toledo, Toledo, Ohio, 43606

William Hyman, Bioengineering Program, Texas A&M
University, College Station, TX 77843

Richard K. Irey, Department of Mechanical Engineer-
ing, University Of Toledo, Toledo, Ohio, 43606

Joseph C. Mollendorf, Mechanical and Aerospace Engi-
neering, State University of New York at Buffalo, Buf-
falo, NY 14260

Chandler Phillips, Biomedical and Human Factors En-
gineering, Wright State University, Dayton, OH
45435

Jonathan W. Pote, Agricultural and Biological Engi-
neering, Mississippi State University, Mississippi
State, Mississippi 39762-5465

Frank Redd, Mechanical & Aerospace Engineering,
Utah State University, Logan, Utah 84322-4130

Thomas Swiontek, Electrical Engineering & Computer
Science, Milwaukee School of Engineering, 1025
North Broadway, Milwaukee, WI 53202-3109

Dick Wilkins, Mechanical Engineering, University of
Delaware, Newark, DE 19716

Gary Yamaguchi, Chemical, Bio, & Materials Engi-
neering, Arizona State University, Tempe, AZ 85287-
6006

FOREWORD

Welcome to the eighth annual issue of the National Science Foundation Engineering Senior Design Projects to Aid Persons with Disabilities. Started in 1988, the National Science Foundation (NSF) began a program to provide funds for student engineers at universities throughout the United States to construct custom designed devices and software for disabled individuals. Through the Bioengineering and Research to Aid the Disabled (BRAD) program of the Emerging Engineering Technologies Division of NSF¹, funds were awarded competitively to sixteen universities to pay for supplies, equipment and fabrication costs for the design projects. A book entitled, *NSF 1989 Engineering Senior Design Projects to Aid the Disabled* was published in 1989, reporting on the projects that were funded during the first year of this effort.

The BRAD program of the Emerging Engineering Technologies Division of NSF increased the number of universities funded to twenty-two in 1989. Following completion of the design projects funded under this initiative during the academic year 1989-90, a second book was published in 1990 describing these projects, entitled, *NSF 1990 Engineering Senior Design Projects to Aid the Disabled*.

In 1991, NDSU Press published a third issue of the *NSF 1991 Engineering Senior Design Projects to Aid the Disabled*. This book described the almost 150 projects carried out by students at twenty universities across the United States during the academic year 1990-91.

NDSU Press published the fourth issue of the *NSF 1992 Engineering Senior Design Projects to Aid the Disabled* in 1993. This book described the almost 150 projects carried out by students at twenty-one universities across the United States during the academic year 1991-92.

NDSU Press published the fifth issue of the *NSF 1993 Engineering Senior Design Projects to Aid the Disabled* in

¹ In January of 1994, the Directorate for Engineering (ENG) was restructured. This program is now in the Division of Bioengineering and Environmental Systems, Biomedical Engineering & Research Aiding Persons with Disabilities Program.

1994. This book described ninety-one projects carried out by students at twenty-one universities across the United States during the academic year 1992-93.

Creative Learning Press Inc. published the sixth issue of the *NSF 1994 Engineering Senior Design Projects to Aid the Disabled* in 1997. This book described ninety-four projects carried out by students at nineteen universities across the United States during the academic year 1993-94.

In 1998, Creative Learning Press Inc. published the seventh issue of the *NSF 1995 Engineering Senior Design Projects to Aid the Disabled* in 1998. This book described one hundred and twenty-four projects carried out by students at nineteen universities across the United States during the academic year 1994-95.

This manuscript, funded by the NSF, describes and documents the NSF supported senior design projects during the eighth year of this effort during the academic year 1995-96. As before, the purpose of this manuscript is to report on the engineering senior design projects developed and implemented through participating schools in this NSF program. Each chapter describes the activity at a single university and, except for the introduction, was written by the principal investigator(s) at that university, and revised by the editors of this publication. Individuals wishing more information on a particular design should contact the designated supervising principal investigator. Additionally, an index is provided so that projects may be easily identified by topic.

It is hoped that this manuscript will enhance the overall quality of future senior design projects directed toward persons with disabilities by providing examples of previous projects, and by motivating other universities to participate because of the potential benefits to the student, school, and community. Moreover, the new technologies used in these projects will provide examples in a broad range of applications for new engineers. The ultimate goal of both this publication and all the projects that were built under this initiative is to assist disabled individuals in reaching toward their maximum potential for enjoyable and productive lives.

It should be evident from reviewing this manuscript that this NSF program has brought together individuals with widely varied backgrounds. Through the richness of these interests, a wide variety of projects was completed, and are in use. A number of different technologies were incorporated in the design projects, to maximize the impact of the device on the individual.

For the most part, a two-page project description format is used in this text. Each project is described with a nontechnical description, followed by a summary of impact that illustrates the effect of the project on the disabled person's life. A detailed technical description then follows. Photographs of the devices and other important components are incorporated throughout the manuscript. Some of the projects are described with a much more extensive description covering many pages; these projects are typically the first or last project in the chapter.

It should be noted that none of the faculty received financial remuneration supervising the building of devices or writing software for the disabled in this program. Each participating university typically has made a five-year commitment to the program.

Sincere thanks are extended to Dr. Allen Zelman, a former Program Director of the NSF BRAD program, for being the prime mover behind this initiative. Additionally, thanks are extended to Drs. Peter G. Kattana, Karen M. Mudry, Fred Bowman and Gil Devey, former and current NSF Program Directors of the Biomedical Engineering and Research to Aid Persons with Disabilities Programs, who have continued to support and expand the program.

We wish to acknowledge and thank Ms. Shari Valenta for the cover illustration and the artwork throughout the book, drawn from her observations at the Children's Hospital Accessibility Resource Center in Denver, Colorado. We also wish to acknowledge and thank William Pruehsner for drawing the technical illustrations used throughout the book and Amy Martin for editorial assistance.

The information in this publication is not restricted in any way. Individuals are encouraged to use the project descriptions in the creation of future design projects for the disabled. The NSF and the editors make

no representations or warranties of any kind with respect to these senior design projects, and specifically disclaim any liability for any incidental or consequential damages arising from the use of this publication. The projects presented here have been implemented in the eighth year of this initiative; they have a wide range of depth and usefulness. Faculty members using the book as a guide should exercise good judgment when advising students.

Readers familiar with previous editions of this book will note that Enderle moved from North Dakota State University to the University of Connecticut in 1995. With that move, the publication also moved from NDSU Press to Creative Learning Press Inc. in 1997. During 1994, Enderle also served as NSF Program Director for the Biomedical Engineering & Research Aiding Persons with Disabilities Program while on a leave-of-absence from NDSU.

New to this edition is co-editor, Dr. Brooke Hallowell, faculty member in the School of Hearing and Speech Science at Ohio University. Dr. Hallowell's background is in neurogenic communication disorders.

The editors welcome any suggestions as to how this review may be made more useful for subsequent yearly issues. Previous editions of this book are available for viewing at the WEB Site for this project:

<http://nsf-pad.bme.uconn.edu/>

John D. Enderle, Editor
Department of Electrical & Systems Engineering
260 Glenbrook Road, U-157
University of Connecticut
Storrs, Connecticut 06269-2157
Voice: (860) 486-5521
FAX: (860) 486-2447
E-mail: jenderle@bme.uconn.edu

Brooke Hallowell, Co-Editor
School of Hearing and Speech Sciences
Lindley Hall 208
Ohio University
Athens, OH 45701
Voice: (740) 593-1356
FAX: (740) 593-0287
E-mail: hallowel@oak.cats.ohiou.edu

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**NATIONAL SCIENCE
FOUNDATION**

1996

**ENGINEERING SENIOR DESIGN
PROJECTS TO AID PERSONS
WITH DISABILITIES**

CHAPTER 1

INTRODUCTION

Devices and software to aid persons with disabilities often need custom modification, are prohibitively expensive, or nonexistent. Much of the disabled community does not have access to custom modification of available devices and other benefits of current technology. Moreover, when available, engineering and support salaries make the cost of any custom modifications beyond the reach of the disabled.

It has been reported that over 35 million people in the United States have disabling conditions. More than 9 million Americans have significant mental or physical conditions that prevent them from being able to carry out the major activity of their age group (that is, play, attend school, work, or maintain a household). These numbers are rapidly increasing due to advances in medicine that extend life expectancy. Today, the average American spends approximately 12 years of his or her life as a person with disabilities. Besides the enormous suffering experienced by the disabled community, disability imposes an enormous cost to the nation, totaling 6.5% of the gross national product (greater than \$170 billion).

Aside from the economic cost to the United States due to disabilities, there is the vitally important consequence of the disability to the individual. Every American has either a disability or direct contact with a person with disabilities (that is, a family member or close friend). Disability ranks as America's greatest health problem in terms of the number of individuals affected and the economic impact.

In 1988, the National Science Foundation (NSF) provided a mechanism, through the Bioengineering and Research to Aid the Disabled program of the Emerging Engineering Technologies Division of NSF, whereby student engineers at universities throughout the United States designed and built devices for persons with disabilities. This NSF program has enhanced the educational opportunities for students and improved the quality of life for disabled individuals.

Students and university faculty provided, through their normal Accreditation Board for Engineering and Technology (ABET) accredited senior design class, engineering time to design and build the device or software, and the NSF provided funds, competitively awarded to universities for supplies, equipment and fabrication costs for the design projects.

This book describes the NSF supported senior design projects during the eighth year of this effort during the academic year 1995-96. The introduction provides some background material on this book, elements of design, and illustrative engineering design experiences at two universities that participated in this effort.

After the introduction, twelve chapters follow, with each chapter devoted to one participating school. The chapters begin by completely identifying the school and the principal investigator(s). Following the chapter introduction for the school, each senior design project description is written using the following format. On page one, the individuals involved with the project are identified, including the student(s), the professor(s) who supervised the project, and the many professionals involved in the daily lives and education of the disabled individual. A brief nontechnical description of the project follows with a summary of the impact on how the project has improved the quality of life of the disabled person. A photograph of the device or the device modification is usually included. Following this, a technical description of the device or device modification is given, with parts specified only if they are of such a special nature that the project could not be fabricated without knowing the exact identity of the part. An approximate cost of the project is provided, excluding personnel costs.

Most projects are described in two pages. However, the first or last project in each chapter is usually significantly longer and contains more analytic content. Individuals wishing more information on a particular

design should contact the designated supervising principal investigator.

The purpose of this publication is twofold. One obvious purpose is to serve as a reference or handbook for future senior design projects. Students are exposed to this unique body of applied information on current technology in this and previous editions of this book. This provides an even broader education typically experienced in an undergraduate curriculum, especially in the area of rehabilitation design. Many technological advances originate from work in the space, defense, entertainment and communications industry. Few of these advances have been applied to the rehabilitation field, making the contributions of this NSF Program all the more important.

Secondly, it is hoped that this publication serves to motivate both students and graduate engineers and others to work more actively in rehabilitation, leading to an increased technology and knowledge base to effectively address the needs of persons with disabilities. In the past, students were typically involved in design projects that enabled students to improve the quality of their lives, for instance, by designing and constructing a stereo receiver. Under this NSF program, engineering students at participating universities are involved with designs that result in an original device or a custom modification of a device that improves the quality of life for a person with disabilities. The engineering design students are provided an opportunity for practical and creative problem solving to address a well-defined need, and the disabled person receives the product of that process. There is no financial cost incurred by disabled persons participating in this NSF program; upon completion, the finished project becomes the property of the individual for whom it was designed.

Under faculty supervision, students developed specific projects, through their senior design classes, to address the identified needs of particular disabled individuals. Local school districts and hospitals participated in the effort by referring interested individuals to the program. A single student or a team of students specifically designs each project for a disabled individual or a group of disabled individuals with a similar need.

The emphasis of the program is to:

- Provide disabled children and adults, student-engineered devices or software to improve

their quality of life and provide greater for self-sufficiency.

- Enhance the education of student engineers by designing and building a device or software that meets a real need.
- Allow the university an opportunity for unique service to the local community.

Some of the projects described here are custom modifications of existing devices, modifications that would be prohibitively expensive to the disabled individual were it not for the student engineer and this NSF program. Other projects are unique one-of-a kind devices wholly designed and constructed by the student for the disabled individual.

Some projects built in years past include a laser-pointing device for people who cannot use their hands, a speech aid, a behavior modification device, a hands-free automatic answering and hang-up telephone system, and an infrared beacon to help a blind person move around a room. The students participating in this project have been singularly rewarded through their activity with the disabled, and justly have experienced a unique sense of purpose and pride in their accomplishment.

Engineering Design

As part of the accreditation process for university engineering programs, students are required to complete a minimum number of design credits in their course of study, typically at the senior level. Many call this the *capstone course*. Engineering design is a course or series of courses that bring together concepts and principles that students learn in their field of study—it involves the integration and extension of material learned in their major toward a specific project. Most often, the student is exposed to system-wide analysis, critique and evaluation for the first time. Design is an iterative, decision making process in which the student optimally applies previously learned material to meet a stated objective.

There are two approaches to teaching engineering design, the traditional or discipline-dependent approach, and the holistic approach. The traditional approach involves reducing a system or problem into separate discipline-defined components. This approach minimizes the essential nature of the system as a holistic or complete unit, and often neglects the interactions that take place between the components.

The traditional approach usually involves a sequential, iterative approach to the system or problem, and emphasizes simple cause-effect relationship.

Another approach to engineering design adheres to treating the problem from a holistic viewpoint. This approach is much easier today with the availability of powerful computers and engineering software packages, and the use of systems theory that addresses interrelationships within the system. Rather than partitioning a project based on discipline-defined components, the holistic view partitions the project according to the emergent properties of the problem.

Design is not a course substitute for the deficiencies that exist in a department's curriculum. It is an approach to problem solving for large-scale, open-ended, complex and sometimes ill-defined systems. The emphasis of design is not on learning new material. Typically, there are no required textbooks for the design course, and only a minimal number of lectures are presented to the student. Design is best described as an individual study course where the student:

- Selects the device or system to design
- Writes specifications
- Creates a paper design
- Analyzes the paper design
- Constructs the device
- Evaluates the device
- Documents the design project

Project Selection

In a typical NSF design project for a person with disabilities, the student meets with the client (a disabled person and/or their client coordinator) to assess the needs of the disabled person and to help identify a useful project. Often, the student meets with many clients before finding a project of interest that suits his or her background.

After selecting a project, the student then writes a brief description of the project for approval by the faculty supervisor. Since feedback at this stage of the process is vitally important for a successful project, students usually meet with the client once again to review the project description.

The team approach is similar to that of an individual student. One or more members of the team meet with one or more clients before selecting a project. After project selection, the project is partitioned by the team into logical parts, and each student is assigned one of these parts. Usually, a team leader is elected by the team to ensure that project goals and schedules are satisfied. A team of students carries out many projects.

Project selection is highly variable depending on the university, and the local health care facilities. Some universities make use of existing technology to develop projects to aid the disabled by accessing databases such as ABLEDATA. ABLEDATA includes information on types of assistive technology, consumer guides, manufacturer directories, commercially available devices, and one-of-a-kind customized devices. In total, this database has over 23,000 products from 2,600 manufacturers and is available from:

<http://www.abledata.com>

or

(800) 227-0216

Specifications

One of the most important parts of the design process is determining the requirements that the design project must fulfill. These requirements are called specifications. There are many different types of specifications, including specifications for hardware and software.

Prior to the design of a project, a statement as to how the device will function is required based on operational specifications. These specifications determine the problem to be solved. The operational specifications completely describe and define the project. Specifications are defined such that any competent engineer is able to design a device that will perform a given function. If several engineers design a device from the same specifications, all of the designs would perform within the given tolerances and satisfy the requirements; however, each design would be different. Specifications determine the device to be built, but do not provide any information about how the device is built. No manufacturer's name or components are stated in specifications. For example, specifications do not list electronic components or even a microprocessor since use of these components implies that a design choice has been made.

If the design project involves modifying an existing device, the device should be fully described in as much detail as possible in the specifications. In this case, it is desired to describe the device by discussing specific components, such as the microprocessor, LEDs, and electronic components. This level of detail in describing the existing device is appropriate because it defines the environment to which the design project must interface. However, the specifications for the modification should not provide any information about how the device is to be built.

Specifications are usually written in a report that qualitatively describes the project as completely as possible, and how the project will improve the life of the disabled person. It is also important to provide motivation for carrying out the project in the specifications. The following issues are also addressed in the specifications:

- What will the finished device do?
- What is unusual about the device?

Specifications also include a technical description of the device, and contain, usually in tabular format, all of the facts and figures needed to complete the design project. The following are examples of important items included in technical specifications.

Electrical Parameters

interfaces
voltages
impedances
gains
power output
power input
ranges
current capabilities
harmonic distortion
stability
accuracy
precision
power consumption

Mechanical

size
weight
durability
accuracy
precision
vibration

Environmental

location
temperature range
moisture
dust

Paper Design and Analysis

The next phase of the design is the generation of possible solutions to the problem based on the specifications, and selecting the optimal solution. This involves creating a paper design for each of the solutions and evaluating performance based on the specifications. Since design projects are open-ended, many solutions exist, solutions that often require a multidisciplinary system or holistic approach for a successful and useful project. This stage of the design process is typically the most challenging because of the creative aspect to generating problem solutions.

The specifications previously described are the criteria for selecting the best design solution. In many projects, some specifications are more important than others and trade-offs between specifications may be necessary. In fact, it may be impossible to design a project that satisfies all of the design specifications. Specifications that involve some degree of flexibility are helpful in reducing the overall complexity, cost and effort in carrying out the project. Some specifications are absolute and cannot be relaxed whatsoever.

Most projects are designed in a top-down approach similar to the approach of writing computer software by first starting with a flow chart. After the flow chart or block diagram is complete, the next step involves providing additional details to each block in the flow-chart. This continues until sufficient detail exists to determine whether the design meets the specifications after evaluation.

To select the optimal design, it is necessary to analyze and evaluate the possible solutions. For ease in analysis, it is usually easiest to use computer software. For example, PSpice, a circuit analysis program, easily analyzes circuit analysis problems. Other situations require a potential design project solution be partially constructed or breadboarded for analysis and evaluation. After analysis of all possible solutions, the optimal design selected is the one that meets the specifications most closely.

Construction and Evaluation of the Device

After selecting the optimal design, the student then constructs the device. The best method of construc-

tion is to build the device module by module. By building the project in this fashion, the student is able to test each module for correct operation before adding it to the complete device, composed of previously tested modules. It is far easier to eliminate problems module by module than to build the entire project, and then attempt to eliminate problems.

Design projects should be analyzed and constructed with safety as one of the highest priorities. Clearly, the design project that fails should fail in a safe manner, a fail-safe mode, without any dramatic and harmful outcomes to the client or those nearby. An example of a fail-safe mode of operation for an electrical device involves grounding the chassis, and using appropriate fuses; thus if ever a 120-V line voltage short circuit to the chassis should develop, a fuse would blow and no harm to the client would occur. Devices should also be protected against runaway conditions during the operation of the device, and also during periods of rest. Failure of any critical components in a device should result in the complete shutdown of the device.

After the project has undergone laboratory testing, it is then tested in the field with the client. After the field test, modifications are made to the project, and then the project is given to the disabled person. Ideally, the design project in use by the disabled person should be periodically evaluated for performance and usefulness after the project. Evaluation typically occurs, however, when the device no longer performs adequately for the disabled person, and is returned to the university for repair or modification. If the repair or modification is simple, a university technician will handle the problem. If the repair or modification is more extensive, another design student is assigned to the project to handle the problem as part of their design course requirements.

Documentation

Throughout the design process, the student is required to document the optimal or best solution to the problem through a series of required written assignments. For the final report, documenting the design project involves integrating each of the required reports into a single final document. While this should be a simple exercise, it is usually a most vexing and difficult endeavor. Many times during the final stages of the project, some specifications are changed, or extensive modifications to the ideal paper design are necessary.

Most universities also require the final report be professionally prepared using desktop publishing software. This requires that all circuit diagrams and mechanical drawings be professionally drawn. Illustrations are usually drawn with computer software, such as OrCAD or AutoCAD.

The two-page reports within this publication are not representative of the final reports submitted for design course credit, and in fact, are a summary of the final report. A typical final report for a design project is approximately 30 pages in length, and includes extensive analysis supporting the operation of the design project. Usually, photographs of the device are not included in the final report since mechanical and electrical diagrams are more useful to the engineer to document the device.

The next two sections illustrate two different approaches to the design course experience. At Texas A&M University, the students work on many small design projects during the two-semester senior design course sequence. At North Dakota State University, students work on a single project during the two-semester senior design course sequence.

Texas A&M University Engineering Design Experiences

The objective of the NSF program at Texas A&M University is to provide senior bioengineering students an experience in the design and development of rehabilitation devices and equipment to meet explicit client needs identified at several off campus rehabilitation and education facilities. Texas A&M has participated in the NSF program for five years. The students meet with therapists and/or special education teachers for problem definition under the supervision of the faculty. The type of design experience offered in this program provides very significant "real world" design experiences, emphasizing completion of a finished product. Moreover, the program brings needed technical expertise to the not-for-profit rehabilitation service providers that would otherwise not be available to them. Additional benefits to the participating students involve their development of an appreciation of the problems of disabled persons, motivation toward rehabilitation engineering as a career path, and recognition of the need for more long-term research to address the problems for which today's designs are only an incomplete solution.

The engineering design experience in the bioengineering program at Texas A&M University involves a

two-course capstone design sequence, BIEN 441 and 442. BIEN 441 is offered during the Fall and Summer semesters, and BIEN 442 is offered during the Spring semester. The inclusion of the summer term allows a full year of ongoing design activities. Students are allowed to select a rehabilitation design project, or another general bioengineering design project.

The faculty at Texas A&M University involved with the rehabilitation design course have worked in collaboration with the local school districts, community rehabilitation centers, residential units of the Texas Department of Mental Health and Mental Retardation (MHMR), community outreach programs of Texas MHMR, and individual clients of the Texas Rehabilitation Commission and Texas Commission for the Blind.

Appropriate design projects are identified in group meetings between the staff of the collaborating agency, the faculty, and the participating undergraduate students enrolled in the design class. In addition, one student is employed in the design laboratory during the summer to provide logistical support, as well as pursue his or her own project. Each student is required to participate in the project definition session, which adds to the overall design experience. The meetings take place at the beginning of each semester, and periodically thereafter as projects are completed and new ones identified.

Faculty feel the needs expressed by the collaborating agencies often result in projects of varying complexity and corresponding time to completion. To meet the broad spectrum of needs, simpler projects are accommodated by requiring their rapid completion, at which point the students move on to another project. More difficult projects involve one or more semesters, or even a year's effort; these projects are the ones that typically require more substantial quantitative and related engineering analysis. Projects are carried out by individual students or a team of two.

Following the project definition, the students proceed through the formal design process of brainstorming, clarification of specifications, preliminary design, review with the collaborating agency, design execution and safety analysis, documentation, prerelease design review, and delivery and implementation in the field. The execution phase of the design includes identifying and purchasing necessary components and materials, arranging for any fabrication services that may be necessary, and obtaining photography for their project

reports. Throughout each phase of the project, the faculty supervises the work, as well as the teaching assistants assigned to the rehabilitation engineering laboratory. These teaching assistants are paid with university funds. The students also have continued access to the agency staffs for clarification or revision of project definitions, and review of preliminary designs. The latter is an important aspect of meeting real needs with useful devices. In addition to individual and team progress, the rehabilitation engineering group meets as a group to discuss design ideas and project progress, and to plan further visits to the agencies.

One challenging aspect of having students responsible for projects that are eagerly anticipated by the intended recipient is the sometimes variable quality of student work, and the inappropriateness of sending inadequate projects into the field. This potential problem is resolved at Texas A&M University by continuous project review, and the requirement that the project be revised and reworked until it meets approval by the faculty.

At the end of each academic year, the faculty and the personnel from each collaborating agency assess which types of projects met with the greatest success in achieving useful delivered devices. This review has provided an ongoing guidance in the selection of future projects. The faculty also maintains continuous contact with agency personnel with respect to ongoing projects, and past projects, that requires repair or modification. In some instances, repairs are assigned as short-term projects to currently participating students. This provides an excellent lesson in the importance of adequate documentation.

Feedback from participating students is gathered each semester using the Texas A&M University student opinionnaire form as well as personal discussion. The objective of the reviews has been to obtain the student's assessment of the educational value of the rehabilitation design program, the adequacy of the resources and supervision, and any suggestions for improving the process.

North Dakota State University Engineering Design Experience

North Dakota State University (NDSU) has participated in this program for five years. All senior electrical engineering students at NDSU are required to complete a two-semester senior design project as part of their study. These students are partitioned into

faculty supervised teams of four to six students. Each team designs and builds a device for a particular disabled individual within eastern North Dakota or western Minnesota.

During the early stages of NDSU's participation in projects to aid the disabled, a major effort was undertaken to develop a complete and workable interface between the NDSU electrical engineering department and the disabled community to identify possible projects to aid the disabled. These organizations are the Fargo Public School System, NDSU Student Services and the Anne Carlson School. Mechanisms are in place so that NDSU students visit disabled individuals or their supervisors to identify possible design projects at one of the cooperating organizations. All of the senior design students visit one of these organizations at least once. After the site visit, the students write a report on at least one potential design project, and each team selects a project to aid a disabled individual.

The process of a design project is implemented in two parts. During the first semester of the senior year, each team writes a report describing the project to aid a disabled individual. Each report consists of an introduction to the project establishing the need for the project. The body of the report describes the device; a complete and detailed engineering analysis is included to establish that the device has the potential to work. Almost all of the NDSU projects involve an electronic circuit. Typically, devices that involve an electrical circuit are analyzed using PSpice, or another software analysis program. Extensive testing is undertaken on subsystem components using breadboard circuit layouts to ensure a reasonable degree of success before writing the report. Circuits are drawn for the report using OrCAD, a CAD program. The OrCAD drawings are also used in the second phase of design, which allows the students to bring a circuit from the schematic to a printed circuit board with relative ease.

During the second semester of the senior year, each team builds the device to aid the disabled individual. This first involves breadboarding the entire circuit to establish the viability of the design. After verification, the students build a printed circuit board(s) using OrCAD, and then finish the construction of the project using the fabrication facility in the electrical engineering department. The device is then fully tested, and after approval by the senior design faculty advisor, the device is given to the disabled individual.

Each of the student design teams receives feedback throughout the year from the disabled individual (or their client coordinator) to ensure that the design meets its intended goal.

Each of the design teams provides an oral presentation during regularly held seminars in the department. In the past, local TV stations have filmed the demonstration of the senior design projects, and broadcast the tape on their news show. This media exposure usually results in viewers contacting the electrical engineering department with requests for projects to improve the life of another disabled individual, further expanding the impact of the program.

Design facilities are provided in three separate laboratories for analysis, prototyping, testing, printed circuit board layout, fabrication, and redesign/development. The first laboratory is a room for team meetings during the initial stages of the design. Data books and other resources are available in this room.

There are also twelve workstations available for teams to test their design, and verify that the design parameters have been met. These workstations consist of a power supply, waveform generator, oscilloscope, breadboard, and a collection of hand tools.

The second laboratory contains Intel computers for analysis, desktop publishing and microprocessor testing. The computers all have analysis, CAD and desktop publishing capabilities so that students may easily bring their design projects from the idea to implementation stage. Analysis software supported includes Microsoft EXCEL and Lotus 123 spreadsheets, PSpice, MATLAB, MATHCAD, and VisSim. Desktop publishing supported includes Microsoft Word for Windows, Aldus PageMaker, and technical illustration software via AutoCAD and OrCAD. A scanner with image enhancement software and a high-resolution printer are also available in the laboratory.

The third laboratory is used by the teams for fabrication. Six workstations exist for breadboard testing, soldering, and finish work involving printed circuit boards. Sufficient countertop space exists so that teams may leave their projects in a secure location for ease in work.

The electrical engineering department maintains a relatively complete inventory of electronic components necessary for these design projects, and when

not in stock, has the ability to order parts with minimal delay. The department also has a teaching assistant assigned to this course on a year round basis, and an electronics technician available for help in the analysis and construction of the design project.

There were many projects constructed at NDSU (and probably at many other universities) that proved to be unusable (and sometimes unsafe) for the intended disabled individual, despite the best efforts of the student teams under the supervision of the faculty advisors. These projects are undocumented to protect the innocent and are best forgotten.

Other Engineering Design Experiences

Experiences at other universities participating in this NSF program combine many of the design program elements that are presented for Texas A&M University and North Dakota State University. In addition to the design process elements already described, the State University of New York at Buffalo under the direction of Dr. Joseph Mollendorf, requires that each student go through the preliminary stages of a patent

application. Naturally, those projects worthy of a patent application are actually submitted. Thus far, a patent was issued for a "Four-Limb Exercising Attachment for Wheelchairs" and another patent has been allowed for a "Cervical Orthosis."

Each of these university programs are unique and offer their own way of implementing student designed and constructed projects to aid persons with disabilities. Other universities participating in this program have many of the elements of design described in this chapter, brought together in their own unique manner.

The senior design projects constructed by these students have proved beneficial to the student, the disabled individual, the community, and the university. The impact of these grants on the student is felt not only during the time of project construction and afterwards in the project's use by the disabled individual, but also in the involvement of these students into community-minded service.



CHAPTER 2

ARIZONA STATE UNIVERSITY

**College of Engineering and Applied Sciences
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Tempe, Arizona 85287-6006**

Principal Investigator:

*Gary T. Yamaguchi, Ph.D. (602) 965-2268
yamaguchi@asu.edu*

A Compact Disc Assistive Device

Designer: Akram Moqbel

Client Coordinator: Ms. Barbara Hightower

National Multiple Sclerosis Society Southwest Branch

Supervising Professor: Gary T. Yamaguchi, Ph.D.

Bioengineering Program

Department of Chemical, Bio & Materials Engineering

Arizona State University

Tempe, AZ 85287-6006

INTRODUCTION

A compact disc (CD) assistive system was designed for a patient with multiple sclerosis. The system consists of two main devices. One device releases the CD from the CD case (releaser), and the other device lifts the CD from the CD case and allows the CD to be placed in the CD player (lifter). The patient places the releaser on his left hand and tightens the Velcro strap around the hand for a snug fit (Fig. 2.1). With the aid of the releaser, the patient can release the CD from the CD case by pushing on the rounded center of the case. The lifter consists of the following components: a cushioned handle, a stainless steel bar, and a tacky adhesive disc. The stainless steel bar is made from a small, telescoping steel pointer to allow the patient to change its length easily depending on how far the CD player is from the patient. The patient holds the lifter in his right hand, places the adhesive disk on the top-side of the CD, and lifts it to the CD player. He can follow the same procedure to lift the CD back from

the CD player to the CD case. A bag, which can be attached to the wheelchair, was made to store the device when it is not in use.

SUMMARY OF IMPACT

Multiple sclerosis (MS) is a disease of the central nervous system (CNS). Some of the primary characteristics of MS are weakness, numbness, visual disturbance, dizziness, ataxia and pain. Some MS patients are not able to grip a CD to release it from a CD case, lift a CD to a CD player, or put a CD away after using it. Multi-disk CD changers are expensive and are difficult to use because the CDs are lying flat and patients cannot pick them up. As a result, a device that assists MS patients to change the CDs in their CD players is particularly helpful. The assistive device described above helps MS patients to change CDs and improves their quality of life. An added benefit is that a small powerful magnet at the end of the lifter, right above the adhesive disk, allows the patient to also



Figure 2.1. The Releaser.

pick up metallic objects (e.g., keys) while sitting in a wheelchair. The compact disc assistive system was designed with a particular client in mind, but this device could be used by anyone who has limited finger dexterity (e.g., arthritis).

TECHNICAL DESCRIPTION

The main design requirements of the system were: 1) it had to function properly in order to improve the quality of life of the patient; 2) it had to be lightweight due to the weakness of MS patients; 3) it had to be affordable; 4) it had to be readily accessible to the user from his wheelchair; and 5) it had to be safe and convenient to use.

The compact disc assistive system has two main devices, the releaser and the lifter (Figures 3.1, 3.2). Both the releaser and the lifter fit easily into a pocket, purse or the bag designed to be attached to the wheelchair. The Releaser is made of hard plastic, cut to shape, heated, and molded to the patient's hand. A rubber tip was fit over its end. On the top of the releaser, there is a space for the hand to be placed in and a Velcro strap tightened around it for a better fit. The



Figure 2.2. The Lifter.

patient can easily push on the center of the CD case to release the CD.

The Lifter does not require any tight gripping, squeezing, or an arm lifting action. The telescoping stainless steel rod reaches from 8 to 34 inches, which allows the user to keep his arms close to his body. The Lifter has a 1.25-inch diameter to eliminate the need for a strong grip. A strap around the back of the hand provides additional stability without requiring muscular exertion. The adhesive/sticky disk attached to the end of the stainless steel rod is made of a tacky rubber compound that will remain tacky for several hundred uses. It is commercially replaceable. A good supply, along with order forms for replacements, was packaged with the unit when it was delivered to the client. A swivel (pin) joint attaching the disk to the rod ensures that flush contact between the tacky disk and the CD will be made without requiring precise alignment.

To lift the CD, the following steps must be followed. First, the lifter rod is extended and the sticky disk is placed somewhere on the CD. Then the disk is pressed gently downward to ensure the proper amount of adhesion. The CD is then lifted slightly. It is released by pushing on the center holding area with the releaser.

Tests on the system were conducted by having the client use it. The device completely and efficiently enabled the patient to perform the relevant tasks. One design modification based on the results of these tests is the addition of the hand strap around the handle of the lifter for comfort and safety.

The final material cost of the compact disc assistive device was approximately \$110, which included an ample supply of tacky/adhesive disks.

Detachable Wheelchair Headrest

Designer: Salem M. Mostofo

Client Coordinator: Ms. Barbara Hightower

National Multiple Sclerosis Society Southwest Branch

Supervising Professors: Gary T. Yamaguchi, Ph.D. and Daryl R. Kipke, Ph.D.

Bioengineering Program

Department of Chemical, Bio & Materials Engineering

Arizona State University

Tempe, AZ 85287-6006

INTRODUCTION

Multiple Sclerosis (MS) is a disease of the brain and spinal cord, characterized by the loss of myelin that surrounds nerve fibers. Its most frequent symptoms are weakness, deteriorating coordination and tremors. Some individuals with MS use a wheelchair for mobility. Standard wheel chairs cost about \$1000. Because of insurance limitations many patients cannot afford more expensive wheelchairs that come with accessories such as headrests, eating trays, etc. Due to weakness and fatigue, MS patients may not be able to sit upright for extended periods of time and thus need to lie back and rest their heads. Therefore, there is a need for an affordable, attachable/detachable headrest that will fit standard wheelchairs. Other wheelchair users would also benefit. It is critical to note that most people who require wheelchairs tend to spend many hours in them. The objective, therefore, is to develop a headrest that is affordable and attachable to standard wheelchairs (Figs. 2.3, 2.4).

SUMMARY OF IMPACT

Some MS patients spend a large amount of time in their wheelchairs. A headrest has been designed as an add-on accessory that helps them to be more comfortable in their chairs. The headrest can be adjusted to a variety of both chairs and patients. It provides the comfort needed and expected by the patient. The contour design of the headrest (Fig. 2.3) provides stress relief of the cervical musculature, which makes it comfortable to remain in the chair for longer time periods. The final design is a useful tool for most wheelchair users and is seen as a potentially helpful device to enhance their quality of life.

TECHNICAL DESCRIPTION

The wheelchair attachable/detachable headrest was designed for one particular MS client, but it can fit any standard wheelchair 14 to 22 inches wide. The head-

rest was designed to be lightweight, affordable, adjustable in height, simple to manufacture, and easy to detach. It was also designed to provide comfortable head and neck support.



Figure 2.3. Detachable Headrest with Client.

The headrest has two main components: the headrest cushion and the rods attaching it to the wheelchair. Two pieces of aluminum tube are welded together to form an inverted "T". Pieces of tubing that are smaller in diameter fit snugly inside the two arms of

the T. Sliding these pieces longitudinally inside the tubes that are larger in diameter accomplishes the length adjustment in both the crosspiece and the vertical support arm. A custom designed clamp is attached to each end of the horizontal crossbar. The crossbar can be adjusted by small increments to fit a wheelchair from 14 to 22 inches by tightening the setscrews. The vertical tubing can also be adjusted and is used to position the headrest cushion at the proper height. The headrest is contoured and custom fit to the client so as to provide some lift at the back of the head.

The client tested the headrest for a short time and found it to be comfortable. The headrest needs to be tested further to determine if the cushion is comfortable for longer time periods.

To start manufacturing the headrest the technical drawings below may be used to communicate to the manufacturer. The following materials are required:

- 24" of aluminum tube (T6061 was used, 1" OD x 1/8" wall); 1 piece @ \$22.00
- 36" of aluminum rod or tube (3/4" OD x 1/8" wall); 1 piece @ \$7.00
- custom aluminum clamps; 2 each @ \$20.00 = \$40.00
- stainless steel set screws; 14 @ \$ 0.69 = \$ 9.66
- custom molded headrest cushion; 1 @ \$ 60.00
- machining and welding services; 2 hours estimated @ \$ 50.00/hr

The total cost to make the prototype was about \$139 dollars excluding labor.



Figure 2.4. Side View of Detachable Headrest.

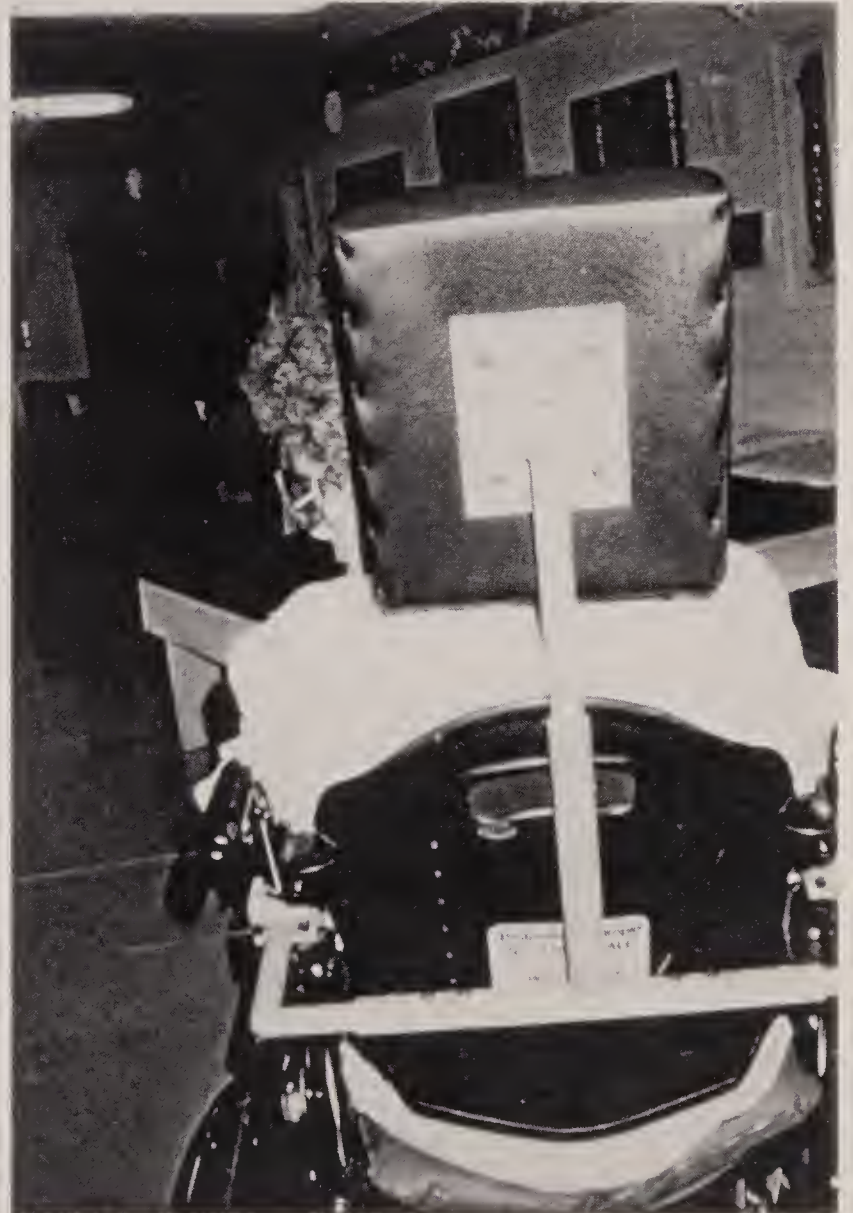


Figure 2.5. Back view of the Detachable Headrest.

Design of a Wheelchair Operable Checkstand

Designer: Ian Rybaczynski
Client Coordinator: Ms. Erika Gehres
Graduate Student, Bioengineering Program, ASU
Supervising Professor: Gary T. Yamaguchi, Ph.D.
Bioengineering Program
Department of Chemical, Bio & Materials Engineering
Arizona State University
Tempe, AZ 85287-6006

INTRODUCTION

A checkstand and register that accommodates wheelchair bound employees has been designed for an employee of Wal-Mart, Inc. The wheelchair accessible checkstand consists of five components: the track system, the chair frame, air cylinders, two steel plates for support, and a pneumatic supply system. The chair frame is mounted on five air cylinders with a steel plate on both the top and bottom of the cylinders to provide rigid support. The steel plate on the bottom is attached to a track system set into the floor so as to be unobtrusive to other checkstand operators. The track system uses linear bearings with a low coefficient of friction so that the chair can be moved easily. Handholds placed on the checkstand allow a person to move freely along the checkstand. The air compressor will allow the air cylinders to raise and lower the chair, and will be stored under the counter in a sound insulated cabinet. The design has been delivered to the client, and awaits an evaluation from Wal-Mart, Inc.

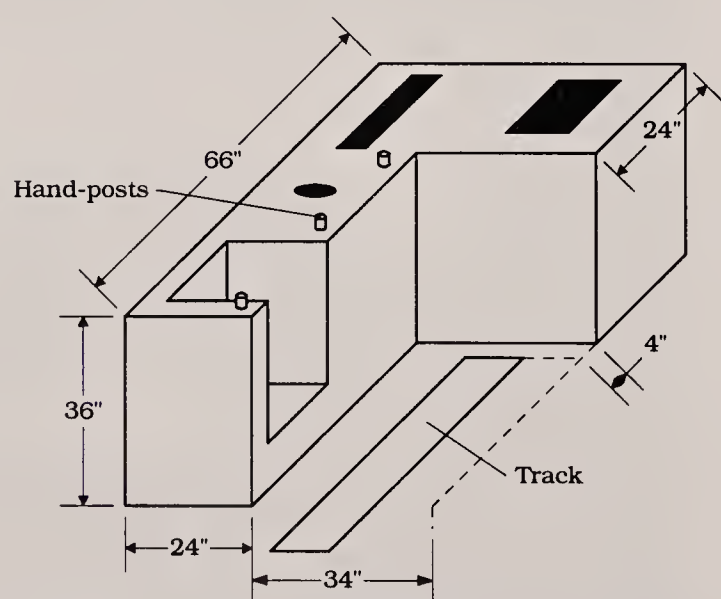


Figure 2.6. View of Wheelchair Operable Checkstand.

SUMMARY OF IMPACT

With the passing of the Americans with Disabilities Act (ADA), businesses must provide reasonable accommodations for their employees with disabilities. Wal-Mart does hire people with disabilities, but those who are not able-bodied are largely unable to work at checkstands because the existing checkstand design does not allow a person in a wheelchair to operate comfortably. This design will give employees at Wal-Mart who use a wheelchair the opportunity to operate a checkstand.

TECHNICAL DESCRIPTION

The wheelchair operable checkstand was designed for an employee at Wal-Mart, Inc., but it may be used by other stores with employees who use a wheelchair and still have the use of their upper body. The main design requirements were: 1) the operator must be able to see and readily use all of the standard register equipment; 2) the operator must be able to transfer in and out and work the checkstand independently; 3) the design must be safe for the user; and 4) the operator must be able to see and greet the customer comfortably. The goals for the design were to create a solution that is independent of the design of the original checkstand, and to ensure that the checkstand can also be used by able-bodied employees.

The wheelchair operable checkstand has five major components: the track system, the chair frame, air cylinders, an air compression and delivery system, and two steel plates. The track system is a Techno Isel Roller Bearing Pillow Block System. It has a 3/4-inch track and can support up to 1200 pounds. The track has a low coefficient of linear friction, which enables the user to easily slide along the length of the checkstand. One end of the track is placed four inches from the side wall of the checkstand allowing a 22-inch excursion outside the working area of the checkstand. This excess track may be used to put the checkstand

chair in a convenient position for transfer to and from a wheelchair. Hand posts are placed along the checkstand to allow the user to move easily from one end of the track to the other. The track system is low maintenance because it only uses the upper half of the roller bearings. This means that even if dust did accumulate along the roller bearings, it would not have an effect on the system.

A 1/4-inch steel base plate is mounted on top of the track system. The air cylinders are bolted to that steel plate to make the system more stable. Five air cylinders are used to prevent the piston rods from bending and binding, ensuring redundancy and safety. If one or two air cylinders break, the other cylinders will be able to operate the chair safely until the broken cylinders can be fixed. The piston rod for the cylinders selected for this application are made out of 3/8 inch stainless steel and the sides are made of 1/8 inch hard coated aluminum alloy tubing. The cylinders are threaded at the bottom and top of the aluminum tube. A 1/8-inch steel intermediate plate with holes for the piston rods is placed over the threaded rods to maintain the vertical, parallel alignment of the rods. The top of the rods are then screwed directly into the underside chair frame.

The air compressor provides up to 220 psi at 1.5 hp. The air compressor, accumulator, and valving will be placed on a shelf enclosed with sound insulation under the counter. Only the pneumatic tubing and wiring for the switch will come out of the compartment.

The switch will be placed on the inside wall of the counter so that the user may activate the compressor. The tubing will enter the arm of the chair where it will be hooked up to a pressure release valve. The release valve will prevent over inflation. From there, the tubing will go to a manifold under the chair that will allow the tube to be divided into five tubes of equal length. These tubes will go to each of the cylinders to provide equal pressure to each of the five cylinders and ensure that the cylinders will work together and lift the chair evenly. Each cylinder can lift 100 pounds. at 100 psi.

The chair seat is 20 inches wide by 17 inches long. The chair back is 18 inches high. The chair does not have any padding so each user can add the appropriate padding to match his or her needs.

The final cost of the parts which includes 5 air cylinders, track slide, 5 foot track, 1.5 horsepower air compressor, chair frame, 1/4 inch and 1/8 inch steel plate, and tubing and other miscellaneous parts is estimated to be \$924, excluding labor.

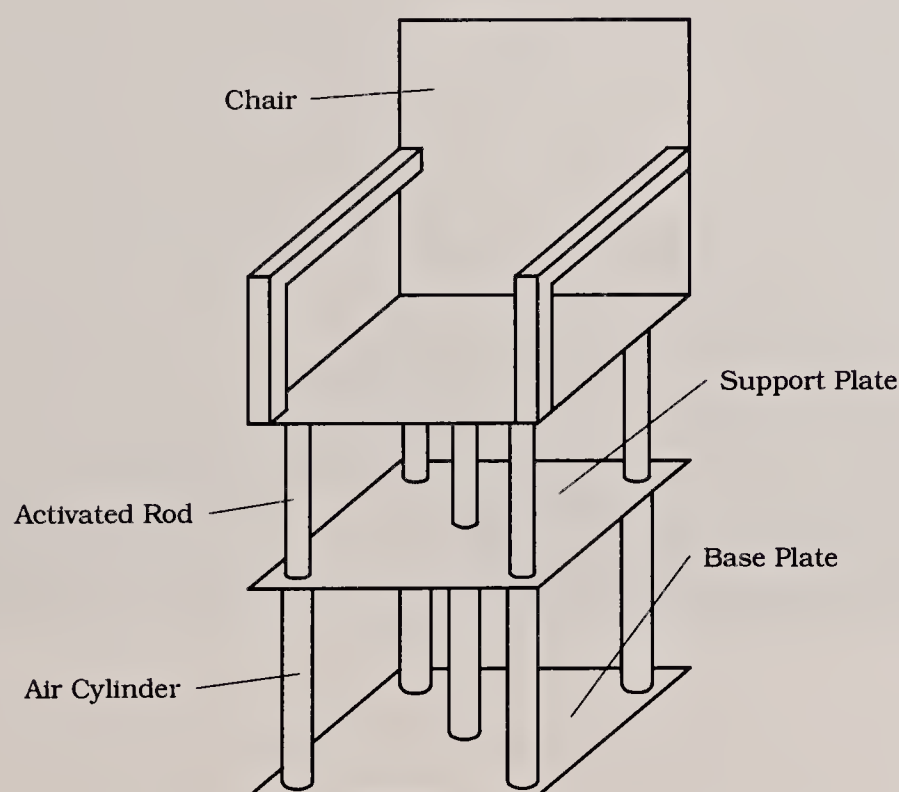


Figure 2.7. Another View of the Wheelchair Operable Checkstand.

A Gear Shifter for an Arthritis Patient

Designer: Nathan Othman

Client Coordinator: Mrs. Cindy Ivy

Physical Therapist, Mayo Clinic, Scottsdale, AZ

Supervising Coordinator: Gary T. Yamaguchi, Ph.D.

Bioengineering Program

Department of Chemical, Bio & Materials Engineering

Arizona State University

Tempe, AZ 85287-6006

INTRODUCTION

A gear shifter was designed for an arthritis patient at the Scottsdale Mayo Clinic. The gear shifter consists of four components: the push button, the gear casing, the steel plate, and the button cover. The gear shifter has a frame similar to the standard gear shifter on the patient's car. The stock gear shifter required the patient to use her thumb to release the gears, but she was unable to do so without letting go of the steering wheel so as to bring both hands to the task. The new gear shifter transfers the releasing force to the palm of the hand, which relieves the weaker thumb from this task. The unit is easy to use, install, remove, and looks like part of the original car.

SUMMARY OF IMPACT

Many arthritis patients cannot do simple tasks because they have limited use of their fingers. Using one finger in isolation can cause severe pain. For instance, the client had difficulty using her thumb to shift the gears in her car. These patients may benefit from having a gear shifter in their car that does not require the use of their fingers or thumb. The gear shifter designed and constructed here met these needs by relocating the previous thumb button gear release to the area contacted by the palm of the hand. This gear shifter is attractive and easy to use, giving the patient the ability to drive a car without causing pain.



Figure 2.8. A Gear Shifter for an Arthritis Patient.

TECHNICAL DESCRIPTION

The gear shifter was designed with a particular client in mind, but could be beneficial to other people with arthritis or other conditions that limit finger and thumb use. The main design requirements of the gear shifter were that it be: 1) painless for the patient to use; 2) easy to use; 3) safe; 4) affordable (having a target price of less than \$150); 5) lightweight; 6) similar in size to the old design; and 7) appearing as it were part of the original car.

The gear shifter has four main components: the push button, the gear casing, the steel plate, and the button cover (Figs. 2.8, 2.9). The push button, the gear casing, and the button cover are machined from PVC plastic. The stainless steel holder is dimensioned at 7 x 3 x .15 centimeters. The cover button is dimensioned at 8 x 4 x 1.5 centimeters. The gear casing is dimensioned at 8

x 9 x 4 centimeters. The press button is dimensioned at 6 x 2.4 x 3.85 centimeters. PVC plastics were used because PVC has a high melting temperature, which is especially critical in the summertime climate of Phoenix, where the user resides.

The final test on the design began with the installation of the device on the patient's car. The gear shifter was installed on the patient's car by taking two screws off the original shift knob, inserting the new design in its place, then reusing the old screws to secure the new device. The patient was very happy with the final design because it met all her requirements and needs.

The material cost of the gear shifter was approximately \$50.



Figure 2.9. Another View of the Gear Shifter for an Arthritis Patient.

Knee Fracture Brace Joint

Designer: Natasha Tomecak

Client coordinator: Mrs. Becky Heffron, CO

Prosthetic Orthotic Associates, Scottsdale, Arizona

Supervising Professor: Gary T. Yamaguchi, Ph.D.

Bioengineering Program

Department of Chemical, Bio, and Materials Engineering

Arizona State University

Tempe, Arizona 85287-6006

INTRODUCTION

A knee joint on a fracture brace, was designed to be adjustable by locking at a variety of flexion angles, was designed. The mechanism was made to allow free motion to the angle of extension and flexion that is set (Fig. 2.10). The total range of the brace includes the normal knee flexion range of 0 to 135 degrees. The state-of-the-art knee fracture brace joint can only lock at 180 degrees and the range of motion is limited to a small number of angles. In the new mechanism, if limited motion is desired, the limits of flexion and extension can be set in 10 degree increments over a 180 degree span, using 3 stainless steel pins.

SUMMARY OF IMPACT

A large number of patients in the United States damage the hard and/or soft tissues of the knees. Knee bracing plays an important role in rehabilitation following injury. A rehabilitative brace is designed to provide a progressive range of controlled motion for persons with knee injuries treated both operatively and non-operatively. These braces offer increased patient comfort because they are lightweight and adjustable for optimal fit. They also permit easy removal and reapplication for wound inspection and rehabilitation. They permit passive and active motion and are used for rigid immobilization when necessary. The angles of limited motion allowed after an injury differ for every individual and are prescribed by the doctor.

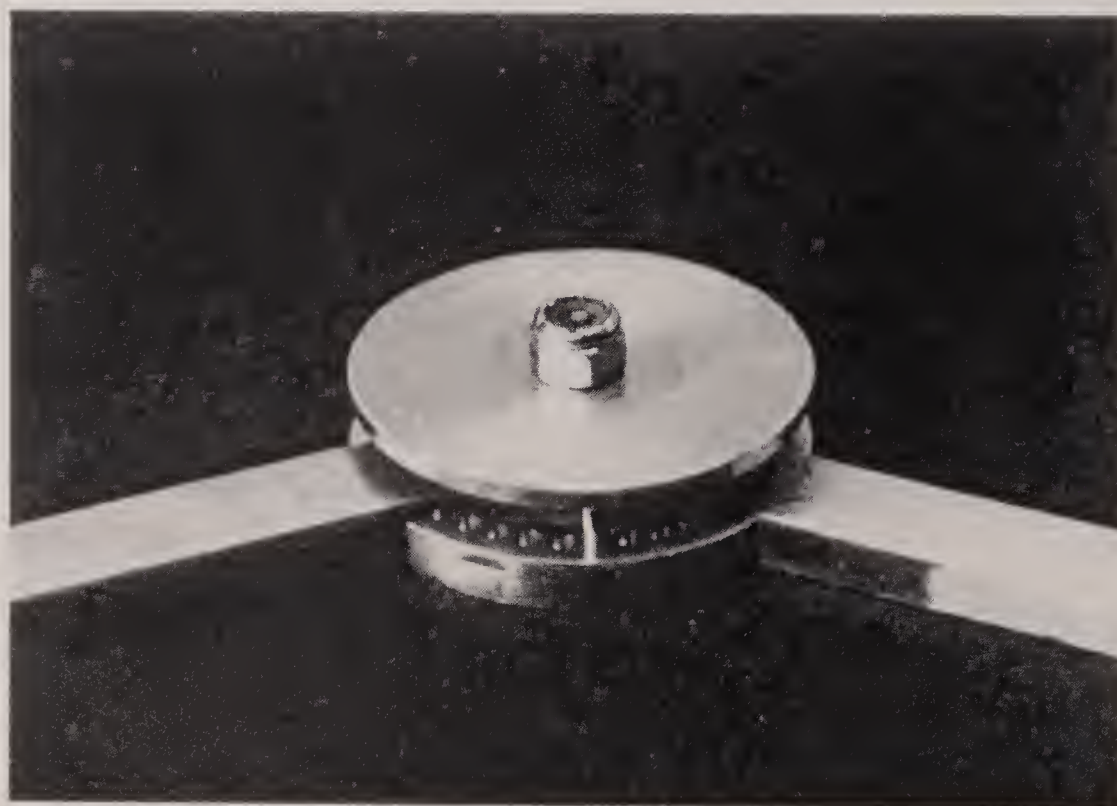


Figure 2.10. Knee Fracture Brace Joint.

In the treatment of knee injuries or following surgery, regaining full range of motion is of primary importance. Two aspects of rehabilitation, continuous passive motion (CPM) and therapeutic exercise done in conjunction with knee bracing, may allow for earlier recovery. CPM following ACL reconstruction has three goals: 1) improved ROM by early passive exercise; 2) control of anterior/posterior drawer forces during the motion; and 3) improved pain management following surgery. Patients can now be fitted with the hinged rehabilitation device so that the ROM can be controlled by the brace while the leg is in the CPM device. Also this improved hinge design gives rehabilitative knee braces the ability to adjust to a wider range of patients and injury conditions.

TECHNICAL DESCRIPTION

The knee fracture brace prototype was built out of balsa wood. Changes were made throughout the construction of the prototype. The changes included the cover design, the number of adjustment angles, and the locking mechanism. The material chosen for the working prototype was aluminum T-6061, currently used in the aircraft industry. This material can withstand a great deal of stress, yet is very lightweight, easily machined, and readily available.

The brace consists of a bar eight inches long, 0.625 inches wide, and 0.125 inches thick. The other part is a bar with a circle attached to it. It is 6.5 inches long, 0.625 inches wide, and 0.125 inches thick. The circle has a diameter of 2.25 inches. There are 25 holes, 0.125 inches in diameter, arranged in a circular fashion. These holes are 10 degrees apart. There is also a cover

of 2.25 inches in diameter, and three 0.125-inch diameter steel pins.

Brace hinges function well in limiting flexion and extension motions. The question arises as to how well they function in alignment with the knee joint. Subjects observed were able to achieve 15 to 20 degrees more extension than the original hinge had allowed, due to play between the soft tissues of the leg and the brace. It is suggested that an extension stop of at least 10 to 20 degrees greater than the desired limit be used for all patients, particularly those in a more active stage of rehabilitation.

A suggested pattern of usage follows. After knee ligament surgery of an athletic person, the extremity should be placed in a brace and locked at 60 degrees. Motion allowed by the brace is encouraged if continuous passive motion is used. A range of 70 degrees of flexion and -40 degrees of extension is set. After 4 days the brace is set at 60-90 degrees. The hinges are adjusted at eight weeks, allowing motion mirroring the motion present in the knee (about 20 to 100 degrees). For at least one year postoperatively, bracing is used for any athletic activities to control rotational instability as well as medial and lateral instability. Patients should be until they can perform normal eccentric and concentric contractions.

This brace joint is compatible with current rehabilitative knee braces. The design meets the requirements and specifications listed by the client coordinator, a certified orthotist. Overall, cost was \$420 for a single unit, including labor, which would decrease significantly in mass production.

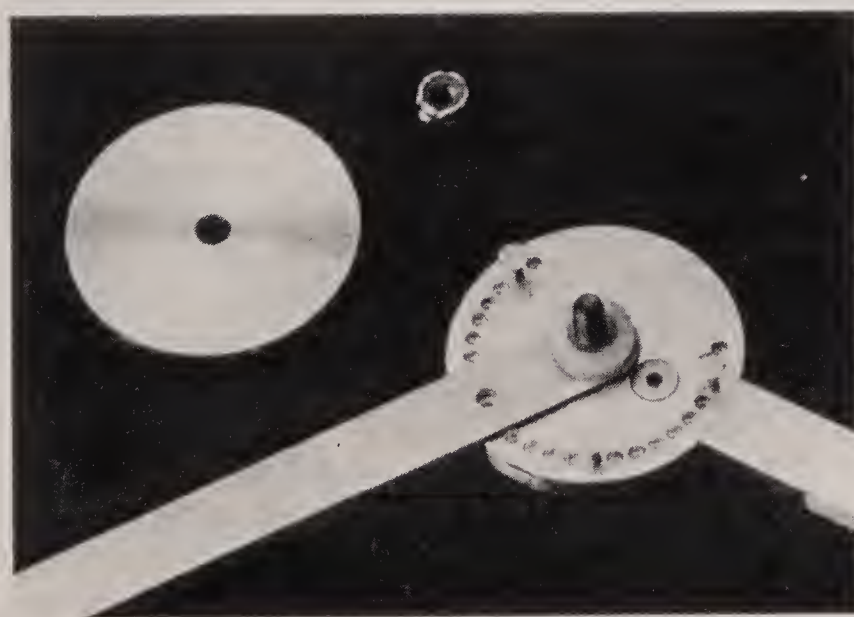


Figure 2.11. Another View of the Knee Fracture Brace Joint.

Laundry: Not A Chore Anymore

Designer: Kelly Jordre

Client Coordinator: Ms. Erika Gehres

Graduate Student, Bioengineering Program, ASU

Supervising Professor: Gary T. Yamaguchi, Ph.D.

Bioengineering Program

Department of Chemical, Bio & Materials Engineering

Arizona State University

Tempe, AZ 85287-6006

INTRODUCTION

A laundry cart has been designed for a person with multiple sclerosis (MS). The cart is a single unit comprised of a clothing receptacle with a handle and wheels attached (Figs. 2.12, 2.13). The body of the cart consists of a rectangular, four-sided metal box frame. A handle extends from the back of the frame of the cart to allow the subject to push or pull the cart. Located at the base of the front of the cart are two metal posts that act as a "kickstand" and will support the cart when the subject is not moving it. The base of the cart is enclosed by five sheets of metal: two on the sides, one on the back, one on the front, and one on the bottom. The two side sheets extend just beyond the height of the wheels to prevent contact with anything that may be transported in the cart. Hanging inside the cart are two full sized laundry bags for easy separation of the clothing articles. The wheels are sized for ease of use in traversing the concrete stairway at the client's apartment building.

SUMMARY OF IMPACT

The patient has a neurological disorder that sometimes causes her left leg and left arm to stiffen up, and that induces episodes of poor balance. During these times, she finds it difficult to walk, especially up and down stairs, and to carry items of significant weight for any length of time. The subject lives on the second floor of her building, and the laundry room is about a block away. These circumstances, combined with her condition, make it extremely difficult for her to do her laundry. Currently she carries a plastic hamper to and from the laundry room, but continues to have difficulty. One can see that what may be a simple chore for some, is very trying and time consuming for her. Ultimately, the patient desires to be able to carry at least two loads of laundry at a time along with all of her various detergent items. The design of this laundry cart will make the chore of doing laundry much simpler for the subject. Not only will it allow her to

carry the desired two loads of laundry plus detergent items to and from the laundry room, but it will also allow for easy mobility up and down the stairs.



Figure 2.12. Laundry Cart.

TECHNICAL DESCRIPTION

The laundry cart was designed with a particular patient in mind; however, the device could be beneficial to any individual needing to transport a variety of different articles. The design of the laundry cart had a number of constraints, but the main design require-

ments were as follows. The design of a device must be "stair friendly." In other words, the subject must be able to get the device up and down the stairs easily. From here, the subject must be able to get the device to and from the laundry room easily. The device also needed to be lightweight. For best results, it was desired that the assembled weight of the cart, plus laundry and detergent items, (total weight) be less than 30 pounds. This thirty-pound limit was based on the subject's estimated load carrying capacity. The device also had to be safe to use. As a final constraint, the cart needed to be sturdy and stable, ensuring that it would not tip over, and that it would support the patient if she lost her balance.

After various brainstorming activities, an initial design was decided upon. Technical drawings were made, and a prototype was designed and built. Unfortunately, at the time of manufacturing, the materials desired for use in the prototype were not available. Consequently, the prototype could not be manufactured as originally specified. The materials used for the manufacturing of the prototype were chosen solely based on availability. As expected, the prototype model alone weighed 43 pounds. (More than the desired maximum total weight). However, if the prototype had been built with the desired specified materials, it would have weighed 24 pounds. The cost of the manufactured prototype cart was \$502.

In the specified prototype, the wheels have a pneumatic configuration with a plane bore hub assembly. This means that the hub assembly is gone and is replaced solely by a steel shaft into which the axle is inserted. As stated previously, differences between the manufactured prototype and the specified prototype lie in the materials and wheels used. The tubing wall thickness and the sheeting thickness used in the manufactured cart were .125 inches and .083 inches respectively, versus the .072 inches and .050 inches specified for the prototype cart. Also, the wheels used in the manufactured cart are of a much heavier-duty construction with a load capacity of 150 pounds, and have a semi-pneumatic configuration with a ball bearing hub assembly. These differences account for the large weight difference between the manufactured and specified carts.

Although the prototype would have ultimately met the original specifications, further investigation

showed that some changes could be made to improve the design. The materials and wheels used in the new design remained the same, but the volume of the new cart was reduced by approximately 50%. In the prototype design, two loads of laundry were viewed as two bags of laundry. In actuality, one bag is more than sufficient to hold two loads of laundry. This would allow the size of the laundry cart to be reduced. In the new design, the cart is estimated to weigh 21 pounds. Assuming that the average load of laundry is approximately 4 pounds, the total weight of the cart and items would be 29 pounds.

Final design drawings have been drafted and all specifications have been determined for the new design. If time permitted, the new design could go on to the manufacturing stage. The final cost of this cart design would be \$440.



Figure 2.13. Another View of the Laundry Cart.

A Shaving Device for Pregnant Women

Designer: Stelios Zarvos

Client Coordinator: Ms. Erika Gehres

Graduate Student, Bioengineering Program, ASU

Supervising Professor: Gary T. Yamaguchi, Ph.D.

Bioengineering Program

Department of Chemical, Bio & Materials Engineering

Arizona State University

Tempe, AZ 85287-6006

INTRODUCTION

A leg-shaving device was designed for a pregnant woman. The device consists of three main components, the locking mechanism, the holder, and the arm. The locking mechanism has two plastic parts that screw together, and between the plastic parts is a tightening ring to ensure a good mechanical lock of the arm to the holder (Figs. 2.14, 2.15). The ring tightens when the two plastic parts screw together, and loosens when the plastic parts are unscrewed, allowing elongation of the shaving device. The holder consists of an aluminum pipe, a grip around the pipe, and an end-fitting plastic cap with a string to hang it up. The grip has anti-slip characteristic under wet conditions so that the device does not slip when the woman is using it in the shower. The arm consists of an acrylic pipe, a small polyvinylchloride (CPVC) pipe, 45° CPVC joint, and a standard safety razor with replaceable blade. The device is safe to use, inexpensive, lightweight, adjustable, and portable.

SUMMARY OF IMPACT

During the last two to three months of pregnancy, the



Figure 2.14. Photograph of the Shaving Device for Pregnant Women in Use.



Figure 2.15. Close-Up Photograph of the Shaving Device for Pregnant Women.

ability of a woman to bend forward or to the side is significantly reduced. Furthermore, the spinal cord carries an eccentric load, because the center of gravity of the woman is moved anteriorly towards the fetus. In many cases of pregnancy the eccentric load leads to back pain that restricts the range of motion even more. As a result, the pregnant woman's task of shaving her legs becomes difficult and potentially can lead to injuries. Both the woman and her unborn child are exposed to the possibility of slipping in the shower or bathtub. The shaving device makes shaving much easier and provides a margin of safety. Also, there are further improvements that can be made on the device, such as attaching a strap to go around the back of the hand, which will make the device usable for persons with arthritis.

TECHNICAL DESCRIPTION

The leg-shaving device was custom designed for a particular client, but could be useful for any woman that has trouble with reaching provided she has no trouble with grasping. The main requirements of the shaving device were that it: 1) reach all areas of the

woman's leg that could be shaved, without requiring her to bend; 2) allow shaving of the leg from 2 inches above the knee down to the ankle; 3) not cause any injury of the skin; 4) be relatively lightweight; 5) be water and mold resistant; and 6) be safe to use.

The leg-shaving device has three main components, the locking mechanism, the holder, and the arm (Figs. 2.14, 2.15). The locking mechanism has two low density polyethylene (LDPE) parts that screw one onto the other with a screw pitch of 0.7 mm. Between the two parts there is a LDPE tightening ring that has an outer diameter of 20 mm and an inner diameter of 16.5 mm.

The holder consists of three parts. The first is an aluminum pipe that has a length of 240 mm and an outer diameter of 23 mm. The second is two neoprene grips that each has a length of 120 mm, an outer diameter of 30 mm, and an inner diameter of 22 mm. The surface of the grip is rough enough to ensure a firm grip in the presence of water. The last part is an end-fitting plastic cap that closes the end of the aluminum pipe.

The cap is glued to the aluminum pipe with silicon sealer.

The arm consists of four parts. The first is a 200-mm clear acrylic pipe, having an outer and inner diameter of 17 mm and 11 mm, respectively. The second part is a 45° CPVC pipe joint, that has an outer diameter of 20 mm and an inner diameter of 17.5 mm. The acrylic pipe is glued into the one side of the joint with CPVC cement. The third part, a CPVC pipe of 40 mm, having an outer and inner diameter of 17 mm and 11 mm, respectively, is glued with CPVC cement into the other side of the joint. The last part of the arm is the shaving razor. It is a Gillette razor with a replaceable blade. The razor is glued into the CPVC pipe with a fast drying epoxy.

The device was tested by the client, a late-stage pregnant woman. She shaved while sitting in the bathtub. The device had a good grip even under water, and it was very easy to use.

The final cost of the leg-shaving device was \$ 34.



Figure 2.16. Components of the Shaving Device for Pregnant Women.

Titanium Knee Joint Locking Mechanism

Designer: Brian Jasper

Client Coordinators: ASU Sports Medicine

Supervising Professor: Gary T. Yamaguchi, Ph.D.

Bioengineering Program

Department of Chemical, Bio, and Materials Engineering

Arizona State University

Tempe, AZ 85287-6006

INTRODUCTION

A common complaint from athletes who wear knee braces is that the brace slows them down because it is too heavy. A knee joint that can be set to lock at any degree of flexion has been designed to help rehabilitate a gymnast following major knee surgery. This titanium device allows the athletic person to return to his or her sport with a very strong, lightweight and compact brace.

SUMMARY OF IMPACT

The design of the knee joint locking brace was discussed with the Sports Medicine staff at Arizona State University (ASU). A brace with a locking knee joint is used in the rehabilitation of medial collateral ligament and anterior cruciate ligament tears. Based on ASU athletic injury statistics, the locking joint developed here (Fig. 2.17), can be used by approximately 70 percent of the athletes with knee sprains. Although the number of serious knee sprains is small compared with the number of overall athletic injuries at ASU, the injuries are serious enough to require a knee brace with a better design.



Figure 2.17. View of Knee Joint on Neoprene Brace.



Figure 2.18. Individual Joint Components.

TECHNICAL DESCRIPTION

The new locking knee joint is made out of medical grade titanium because it has extremely strong integral properties and is very lightweight. The titanium was machined into three pieces (Fig. 2.18) out of a single 1/8" x 1.5" x 24" bar. Two served as the femoral and tibial components, and the third became the adjustable locking mechanism that actually determines the degree at which knee flexion will stop (Fig. 2.19). This design gives the athlete (Fig. 2.20) 28 different adjustments for the range of motion between 0 (full extension) and 135 degrees, in five-degree increments. This is an improvement in adjustability over previous, commercially available designs.

The knee joint was tested by the client, a gymnast at ASU. Testing showed that the joint would hold up to the force the athlete applies during his rehabilitation period. However, the testing also showed that the locking grooves needed to be deeper so that the locking mechanism would not slip out of position during shock loading.



Figure 2.19. Back View of Knee Joint.

The cost of the actual joint is \$254 for the titanium, and \$6 for the Velcro to attach it to the neoprene. The overall material cost of the joint is \$260, excluding labor. Machining costs are somewhat higher than for aluminum, and similar to machining costs for stainless steel.



Figure 2.20. Knee Joint in Use.



CHAPTER 3

BINGHAMTON UNIVERSITY

**Thomas J. Watson School of Engineering and Applied Science
Department of Mechanical Engineering
Binghamton, NY 13902-6000**

Principal Investigator:

*Richard S. Culver (607)777-2880
rculver@binghamton.edu*

Corrective Hand Brace

Designers: Michele Ferland, Michele Parks, Patrick Simpson

Client Coordinators: Daniel Cullin

Southern Tier Independence Center

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

The purpose of this project was to design corrective braces for people with multiple sclerosis who experience contractions of the hand during the night. The aid was designed to prevent the excessive cramping that occurs in the finger muscles during involuntary contraction. The braces are lightweight, ventilated, durable, and allow movement of the thumb and wrist.

SUMMARY OF IMPACT

After using the braces for one week the client was satisfied with the results. Before having the braces, she would spend up to an hour each morning massaging her fingers to help release painful contractions that caused her fingers to lock into a curled position. The client has reported that since using the braces, her fingers remain a little stiff but are moveable. In general, the braces are a success in the sense that her hands are usable in the morning, unlike before. However, she does feel that the braces need extra protection around the edges. There will be padding added to the braces to prevent any injury during the night. Neoprene will most likely be the padding used and it will be attached around the edge of the brace at the fingertips.

TECHNICAL DESCRIPTION

The braces have a simple design. They are made from Polypropylene thermoplastic that covers the hand from the heel of the palm to the fingertips. These braces are attached to the hand with cotton straps and Velcro. The straps are wrapped around the hand twice, once around the back of the wrist and then

again over the knuckles. Two snaps are used to attach the straps to the thermoplastic. They can be released to allow for easy cleaning of the braces.

Since the braces are to be worn while sleeping, their design should allow for users to wear them as comfortably as possible for extensive periods of time. The optimal brace should be molded to the natural resting curvature of the hand and be adjustable. Choosing a material that is capable of remolding was beneficial to the final design. The person who uses these braces and finds any particular section uncomfortable can readjust that section using a hairdryer. After the section is hot enough and adjusted to the desired fit it can be hardened by placing it in cold water. This process should take no more than ten minutes. The benefit of using a hairdryer is that the heat does not affect the whole brace.

The designed brace is made from a 1/8-inch sheet of Polypropylene thermoplastic. The plastic is ventilated by pre-punched holes 1 inch apart and 1/8 inch in diameter. The final built design is 5 7/8 inches long, 4 inches wide and 2 1/2 inches tall. The curvature of the brace allows the fingers to rotate downward approximately 65 degrees, which allows natural, comfortable positioning for the fingers. The sides of the braces are turned upward to add support to the sides of the hands. They are secured to the hand with cotton straps and Velcro. These straps are modified boxing wraps made of 100% breathable cotton. They have a length of 24 inches. Since they are not permanently secured to the brace they can be removed to allow the cleaning of the plastic and straps.



Figure 3.1. Corrective Hand Braces.

Crawling Support

Designers: Marcela Arana, Dale Burmingham, Harry Misichronis

Client Coordinators: Judy Zeamer

High Risk Birth Clinic

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

A crawling device was designed for a two-year-old girl with cerebral palsy. Due to weakness in her arms and legs, the girl cannot support her own body. Consequently, she cannot maintain her body in a crawling position without support. This device assists her in maintaining the crawling position so that she can practice crawling without the assistance of another person.

SUMMARY OF IMPACT

Due to weaknesses in her limbs, the child does not have the strength required to sustain her body in a crawling position. This causes her to distort the position of her body and attempt to crawl incorrectly. With this device, the burden is removed from her limbs so that she is much more likely to learn to crawl properly. The correct techniques will help her eventually learn the skills needed to walk on her own.



Figure 3.2. Crawling Support.

TECHNICAL DESCRIPTION

The crawler consists of a rectangular PVC frame attached to four fully rotational wheels. A cloth is attached to the frame by four vertical uprights coming off the base. The device is designed so that the child's torso rests on the cloth while her hands and knees are on the ground. The wheels allow her to propel herself with her hands and knees across a floor with little effort. With her body firmly supported by the cloth, her weight does not fall on her limbs. With this device, she can practice her crawling skills successfully since her weight does not interfere with the movement of her arms.

As the child crawls on the floor using the device the weight of her body is distributed symmetrically onto the four uprights. The symmetrical design ensures that the crawler will remain balanced and that it will seldom tilt in any direction because her weight serves as load acting on the geometrical center of the crawling aid. A sturdy device permits a safer and more comfortable ride. The wheels are placed on the sides of the device away from the child's hands.

Another important feature of this crawling aid is that the height from the ground to the top surface of the

crawler can be adjusted. Two vinyl straps beneath the cloth support can be loosened or tightened as desired. Loosening the straps causes the cloth to loosen, decreasing the overall height of the crawler. Additionally, two sets of progressively longer uprights were presented to the client so that the device can be later adapted to allow for the child's continued growth, thereby ensuring that she will be able to use it for a long time. By simple removal of some screws, the PVC pipes can be replaced with longer or shorter pipes as needed.

The cloth support, the casters and miscellaneous screws and nuts cost a total of \$35. A professional upholsterer was called upon to sew the fabric for the device. The PVC tubes used for the frame were obtained without charge from a Binghamton University machine shop. Had this material been purchased, the total cost of the supplies would have come to \$45. Commercial crawling aids are available from various manufacturers at costs ranging from \$150 to \$300. By purchasing the raw materials and assembling the device, over \$100 was saved.



Figure 3.3. Client Using Crawling Support.

Large Desktop and Storage Area Desk for a Young Child

*Designer: Ben Rosenkrans
Client Coordinators: Donna Boisvert
Tioga Hills Elementary School
Supervising Professor: Richard Culver, Ph.D.
Department of Mechanical Engineering
Binghamton University
Binghamton, NY 13902-6000*

INTRODUCTION

A large desktop and storage area was designed for a young child with cerebral palsy. The desk involved modification of an existing classroom desk rather than use of all new materials, to help the child as well as the other children in his class adjust easily to the new design. A folding surface on the left side of the desk, supported by a folding table brace. When pulled out, it allows for additional support on the left side. The right side of the desktop folds up to the right for easy access to the storage area inside the desk. Also, a wire basket is mounted on the right side of the desk for additional storage.

SUMMARY OF IMPACT

A seven-year-old boy with cerebral palsy has difficulty gripping things with his right hand and has a

brace on his right leg for support. His previous classroom desk consisted of two regular desks pushed together for a larger desktop, and a Rubbermaid container on top for book storage. He had occasionally fallen out of his chair because he had no support on his left side. The boy's physical therapist recommended some type of support on which he comfortably could rest his left arm to prevent him from falling again. The boy was being encouraged to use his right arm and hand more to develop movement. The new desk provides a larger desktop that allows for two books opened next to one another on its surface. It also provides support for the boy's left side and an easily accessible storage area.

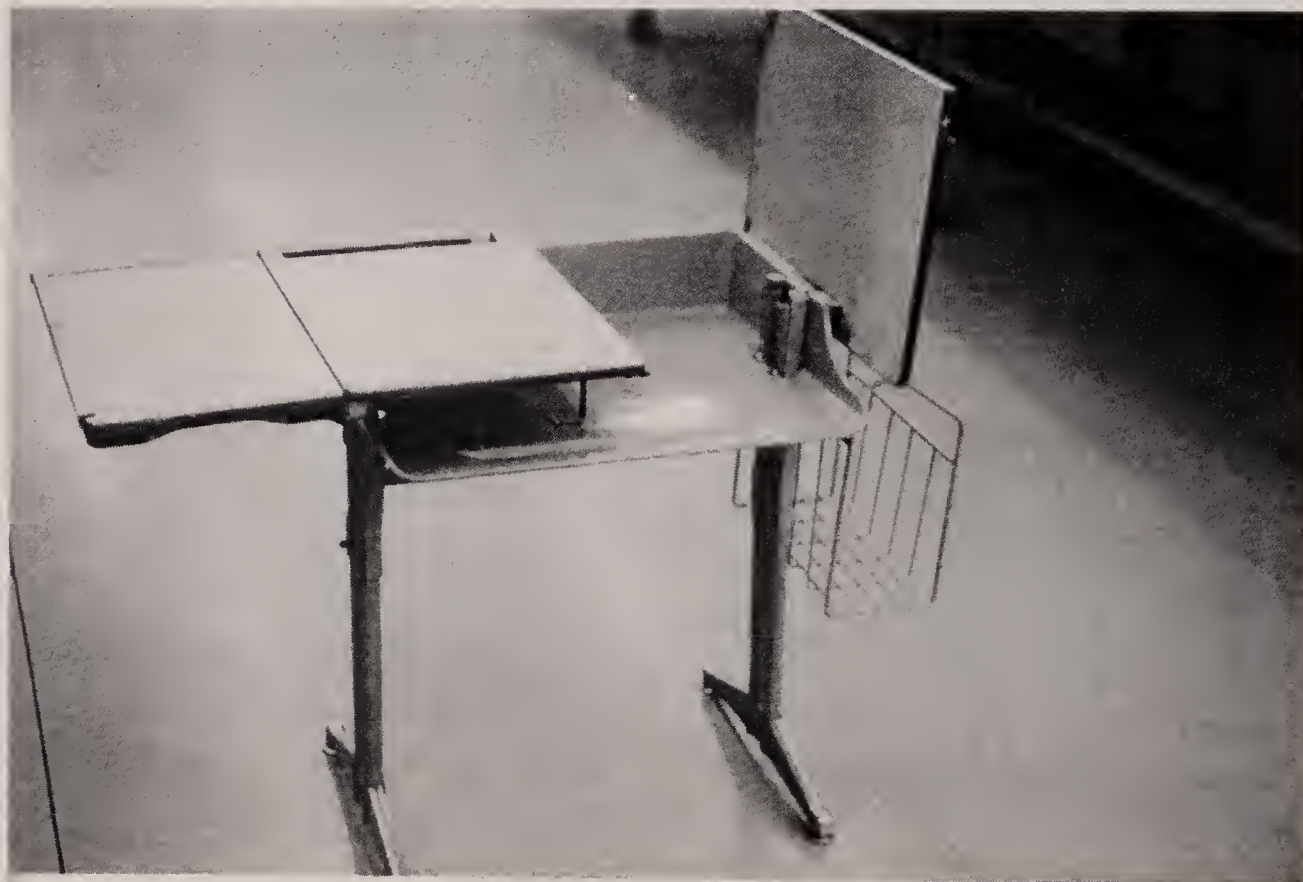


Figure 3.4. Large Desktop and Storage Area Desk.

TECHNICAL DESCRIPTION

The desk is modified from an existing classroom desk to make it look as much like the rest of the children's desks as possible. The frame and legs are exactly like the rest of the desks, with the exception of a brace between the legs. The purpose for the brace is to give the desk more durability. The brace consists of a piece of pipe serving as a spacer between the legs. A piece of threaded rod running inside the pipe extends through a hole in a brace on each leg; it is tightened down with a hex nut and lock washer on each end. The desktop material is a pressboard base with Formica coating on top, taken from an existing desk to ensure similarity to the other desks in the classroom.

The right side of the base of the desktop is hinged, allowing easier access to the desk's inside storage area. The right side rests on a steel plate that is attached to the bottom of the stationary portion of the desk for support. A rubber stopper is attached to the outer right side of the desk to prevent the hinged top from bending too far. A ten-inch wide folding section is attached to the left side of the desk to provide a larger workspace area. It is equipped with a folding table leg brace for support that allows the child to fold the section up and down. The folding section consists of

two pieces of desktop on top of each other, with slots located in the bottom piece. Four bolts screw into the bottom of the top piece through the slots, allowing the top piece to slide forward toward the child for support.

A wire storage basket is attached to the right leg of the desk to provide an additional storage area. A brace around the desk's leg is adjustable, allowing the basket to be raised and lowered. The basket can be removed from the desk to allow legs of different sizes to be attached to the desk. A groove was cut into the stationary left side of the desk for storage of pens, pencils, etc. The groove has an extension to the edge of the desk surface to allow for easy cleaning. Edging was placed around the outside perimeter of the desk to prevent objects from sliding off. The edging is made of wood molding with a varnish applied to the finish. The edging is attached with nails to the side of the desk.

The total cost of materials for the desk is about \$100. This price includes painting supplies, film, and hardware for the desk. Two existing desks were donated by Tioga Hills Elementary School for use in the project.

Adaptive Tricycle

Designers: Herbie Mann, Chris Kuntz, Susan Tewksbury

Client Coordinators: Renee Packer

Handicapped Children's Association

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

An adaptive tricycle was designed for a three-year-old girl with cerebral palsy. She cannot operate a tricycle by herself. The purpose of this project was to modify a standard tricycle that she can operate independently and use effectively to improve her strength.

SUMMARY OF IMPACT

The client is a three-year-old girl with cerebral palsy. The physical therapist (PT) currently works with her on a tricycle to help her develop her outside leg muscles. The PT must help support the girl's upper torso and push her along as she attempts to pedal. She enjoys riding the tricycle, and both the PT and the girl's mother think it will be an enjoyable way for her to get the therapy she needs. The goal was to get the child to walk without the use of a walker, which she currently needs. The adaptive tricycle enables her to exercise her legs while engaging in an activity she likes.

TECHNICAL DESCRIPTION

The child for whom the tricycle was designed is approximately three feet tall. She has limited use of her legs, is deaf, and has not learned to speak, although she is beginning to learn sign language. Her legs tend to cross at the knees in a scissors-like manner. She is unable to sit up straight without additional support.

A standard tricycle was purchased and modified. A back support of PVC pipe was added, along with two nylon straps and a Velcro fastener, to belt the client in at the chest and waist. Blocks were added to the pedals to shorten the leg reach. Two straps and a heel guard were attached to the pedal blocks to keep the child's feet in the proper position. The pedal blocks were made from two square pieces of wood, so that one can be removed as the child gets taller. A vinyl variable anti-scissoring device was created and attached to the center bar. Upright handlebars were then attached to the existing handlebars to further



Figure 3.5. Adaptive Tricycle.

help her maintain an upright position. An adjustable bolt attached to the front fork over the front wheel was added to create friction on the front tire to vary the resistance. The seat and handlebars can be raised to accommodate the child as she grows.

In the process of developing this design, a two-wheel bicycle with training wheels was considered. Resistance would have been easier to develop and the bicycle would have been more stable. However, the client

was unable to pedal the two-wheel bicycle because the pedals were underneath her instead of in front of her. Another alternative considered was a four-wheel car with push pedals to propel it. This concept was not chosen because of the difference in motion required to pedal the car relative to the tricycle. One of the main goals of this design was to create some type of bicycle that would aid in developing the outside leg muscles of the client. A pushing motion would not accomplish this to the degree that a rotating motion would.

The design involves an adaptation of a standard tricycle and allows the child to operate the tricycle inde-

pendently. This design will also enable the PT to vary the resistance in an effort to strengthen the child's legs. She will then be able to concentrate on pedaling the tricycle since she will be adequately supported and secured on the tricycle.

The final cost of this project is \$70. The standard tricycle costs \$33, with the additional parts needed to modify the tricycle totaling \$37. The cost of adaptive tricycles currently on the market range from \$500 to \$900, making this design more practical and affordable for the client.

Computer Mouse Modification

Designers: Michelle Cristofaro, Michael Feinberg, Lucy Zhang

Client Coordinators: Bonnie Cole

Handicapped Children's Association

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

A computer mouse was modified for handicapped children between the ages of 18 months and 4 years. The children using the mouse for an Apple 2E computer tend to move it erratically and click too quickly on the button. The mouse can only be controlled with one hand since some of the children have limited hand movement. The mouse has to be easy for them to use so they can concentrate better on the program they are using.

SUMMARY OF IMPACT

Conversations with a client coordinator and observations of children using the standard mouse led to an understanding of the children's problems with the mouse. When they touched it, their fingers automatically touched the top of the button. As a result, they were clicking on it without even knowing it, which caused the program they were working with to do things they did not want it to do. Also, the mouse was getting turned around in different directions; it wouldn't always move in the same direction on the screen, which caused confusion. The children also picked up the mouse off the table or moved it randomly. It is thus important to control its range of motion.

TECHNICAL DESCRIPTION

An arm, fashioned after a drafting machine, was mounted on a 19 by 17-inch piece of Lexan plastic, covered with four foam rubber "mouse" pads. The arm is made out of two sets of two parallel 1/4 by 1/2-inch aluminum bars. The arms are heavy enough to control the motion, while strong enough to endure heavy use by the children. On the end of the arm is a Lexan bracket that holds the mouse and orients it properly. This design can be used with any standard-sized mouse. On the top of the bracket, a ball is mounted on a one-inch wide strip of plastic that fits over the top of the mouse. The children will grab the ball, and since their hands are so small, they will not be able to click the button unless they pick their hands up completely off the ball. The plastic strip also prevents the mouse from being lifted out of the bracket. The screws attaching the arm to the mouse pad surface can be tightened in order to make movement of the mouse more difficult.

The new design works well for handicapped children. It keeps the mouse in the right orientation while also limiting the motion so the children don't become confused. Hence, they are able to concentrate more on learning with the program they are using on the computer than on how the mouse works.

The total cost of the modified computer mouse is \$91.

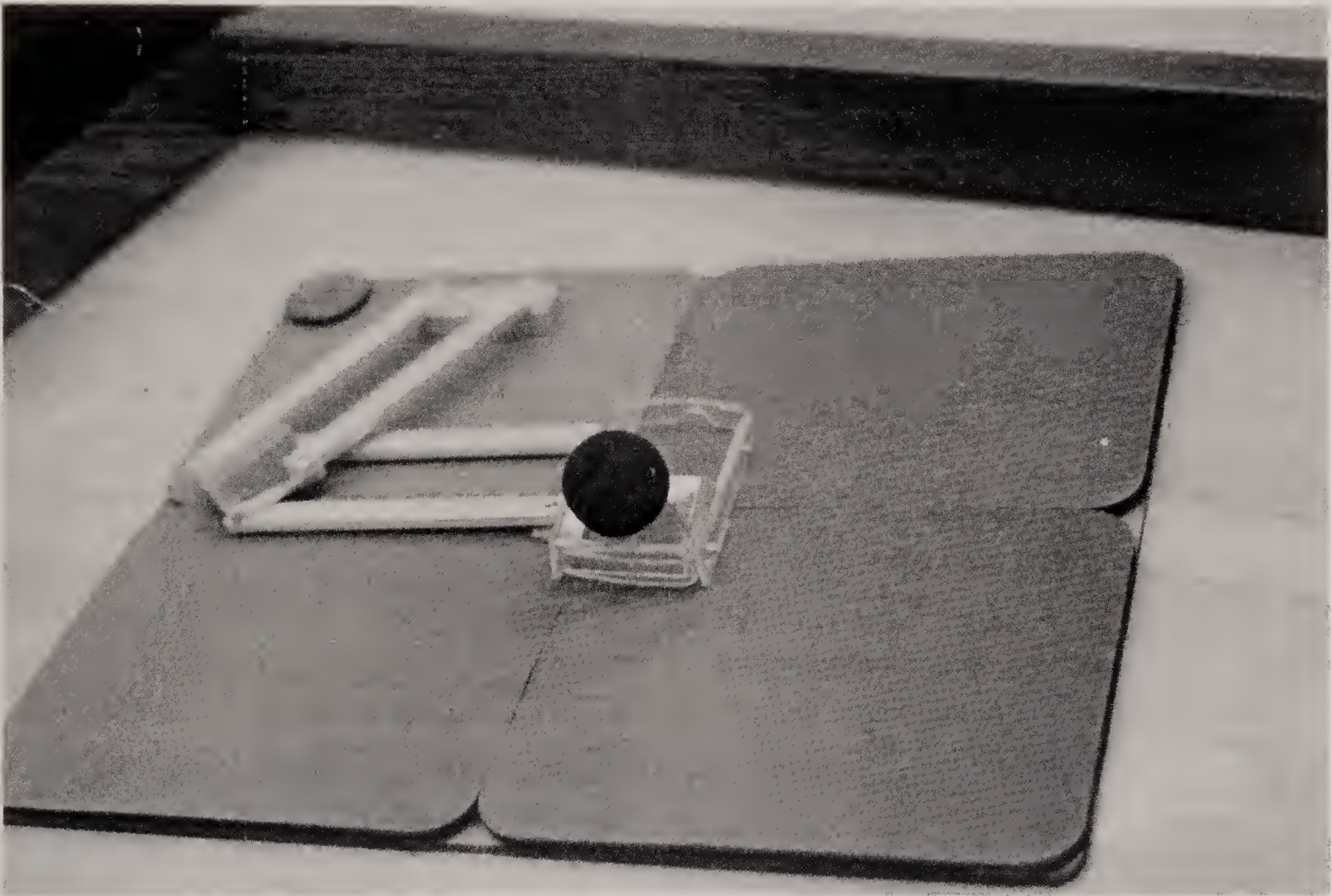


Figure 3.6. Modified Computer Mouse.

Standing Aid Design A

Designers: Robert Brathwaite, Michael DeBlasis, Matthew O'Connell

Client Coordinators: Eric Lopez, Binghamton University

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

The standing aid will assist a paraplegic adult in the upright position. This version (Design A) is designed for self-reliance. Although the aid is large in size, it is collapsible, which makes it portable to some degree. This device is also constructed for working environments.

SUMMARY OF IMPACT

The device meets the basic needs of the client. The device must support the body of a person who cannot

stand up. As the client is independent, a feature was added to assist him in standing in and out of the device. It includes a safety mechanism that will prevent him from falling. The device is portable when collapsed. The client will be able to separate the standing aid into several components and transfer it. The device can also be used as a workstation; giving the client the opportunity to work, eat, and perform many other activities.

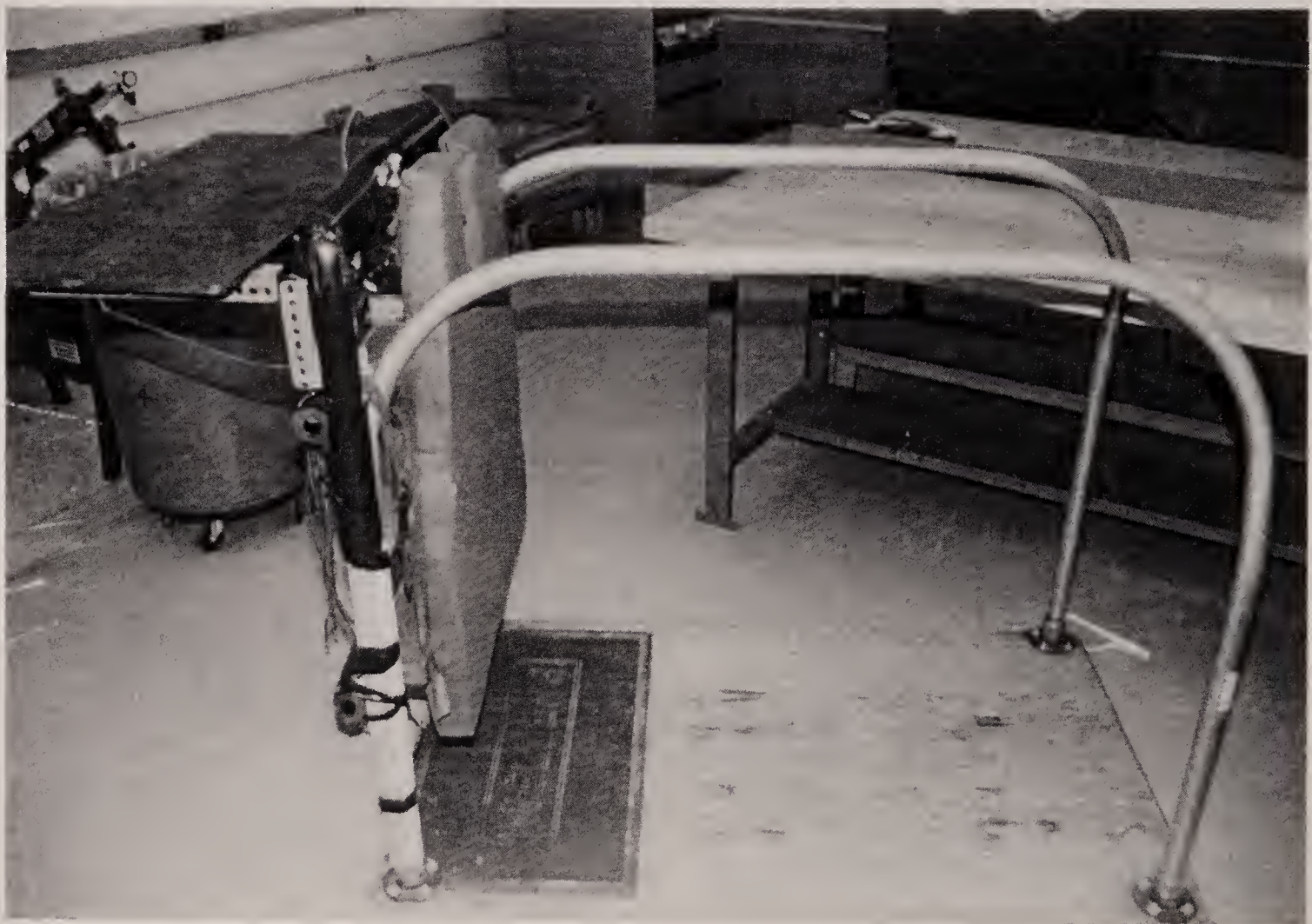


Figure 3.7. Standing Aid Design A.

TECHNICAL DESCRIPTION

Design A is a shortened set of parallel bars with a front board. The bars are bent inward 75 degrees for a more comfortable lifting process for the client. The front board is composed of an angle iron, a pad, a winch, several bungee cords, and a wooden table. Angle irons are used for the front cross support that is bolted to the side of the bars. Attached to the angle iron is a winch, which is a safety feature the client requested. While he is lifting himself into the standing position, a bungee cord is used to pull up the slack in the winch strap. The retraction of the winch is powered by the bungee cords that are wrapped around the spindle of the winch while the cable is retracted. The tension of the bungee cords is enough to retract the slack in the cable while the user pulls himself up along the parallel bars. The winch has a self-locking mechanism that will prevent the user from falling to the ground in case he loses his grip. At the side of the pad there is a release lever which runs through a cable to the release latch on the winch. This lever is needed since the table is blocking the winch.

The table is made of plywood and is padded. At the client's request, the table is two feet wide by one and a half feet deep. The frame is steel and is extremely strong. Steel was chosen over PVC because a large moment is produced at the feet during the lifting process. Once standing, there is very little stress on the other frame components.

The final cost of Design A is \$150.

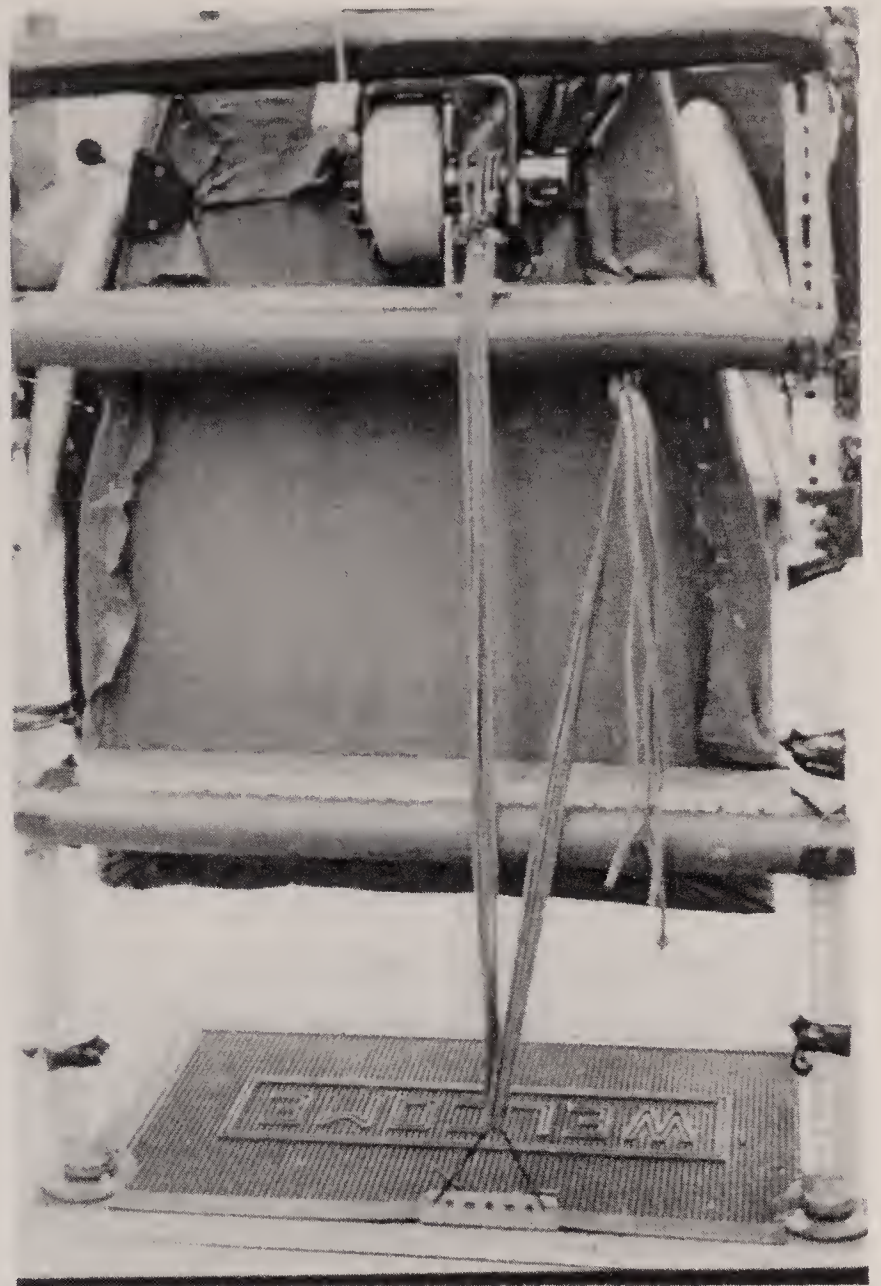


Figure 3.8. Rear View of Standing Aid Showing Winch.

Standing Aid Design B

Designers: Robert Brathwaite, Michael DeBlasis, Matthew O'Connell

Client Coordinators: Russ Smith, Chenango Valley Industries

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY the 13902-6000

INTRODUCTION

The standing aid will assist a paraplegic person in the upright position. This version (Design B) is designed for users who have assistance from others in getting in and out of the device. Design B is much smaller, lighter, and portable in comparison to Design A. Although the aid is large, it is collapsible, which makes it portable to some degree. This device is also constructed for working environments.

SUMMARY OF IMPACT

The design of this device was based on the basic needs of the client. The device must support the body of a person who cannot stand up. The client is not fully independent, and will require assistance getting into and out of the device. The device is portable when collapsed. The client will be able to disassemble the device into several components and transfer it.

The standing aid can also be used as a work station, giving the client the opportunity to work, eat, and perform many other activities while in the device.

TECHNICAL DESCRIPTION

Design B consists of a PVC frame, a padded board, a plywood base, a Velcro harness, and a wooden table. The PVC frame can be detached from the plywood base via four hitch pins. These two sections of the aid are then transportable. The Velcro harness was tested at 100 lb. The PVC frame was used because of its smooth edges and its ease of assembly. Unlike design A, this design will not have a large bending moment about the feet during lifting.

The final cost of Design B is \$68.

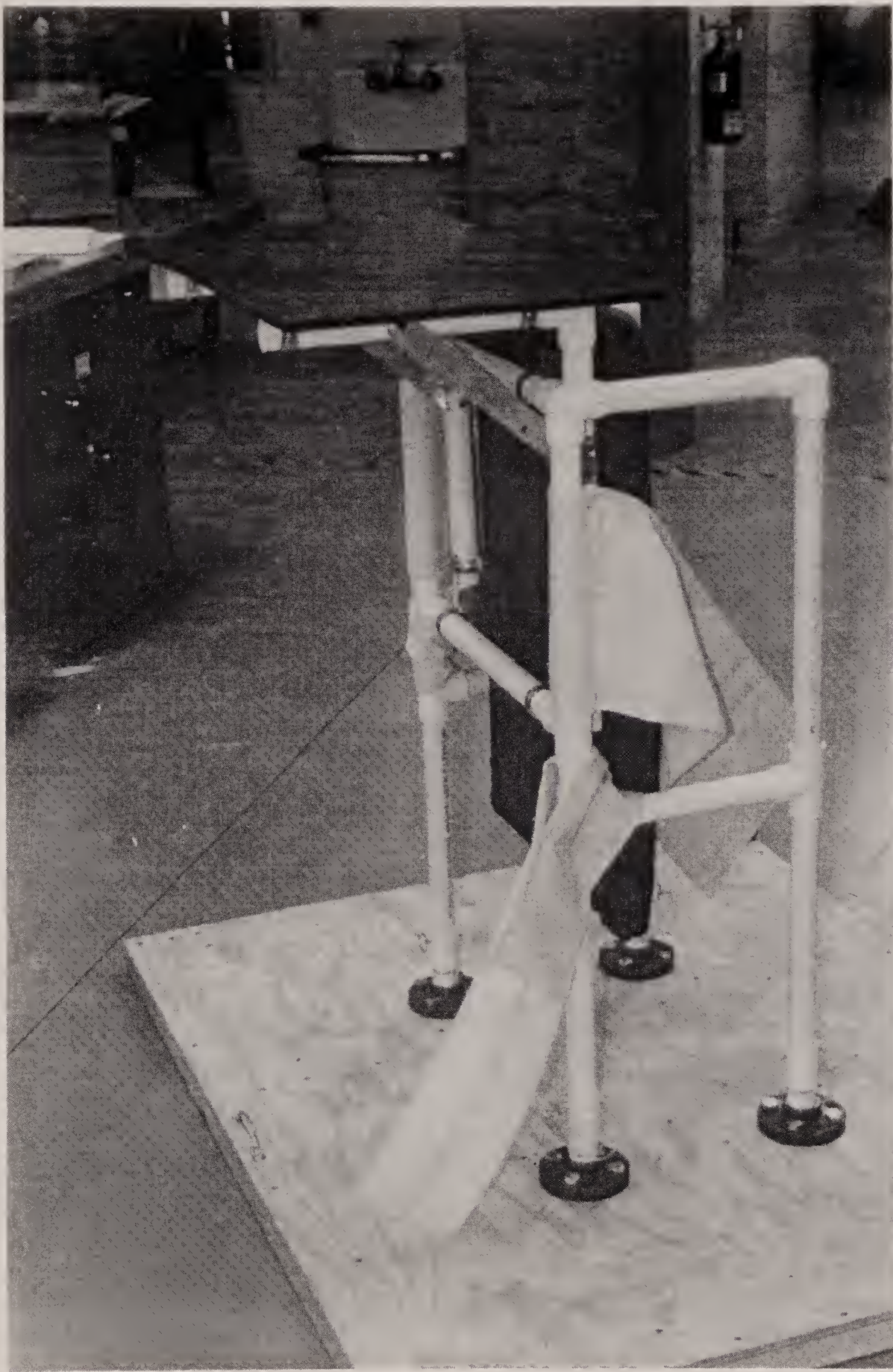


Figure 3.9. Standing Aid Design B.

Wheelchair Lift

Designers: Michael Ballou, Danielle Gorlitsky, Kahlil Zaloom

Client Coordinators: Daniel Cullin

Southern Tier Independence Center

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

An adult male with multiple sclerosis recently moved to a home with a seven-inch step between the house and the attached garage. Since he is confined to a wheelchair, this step poses a problem. Initially, it seemed that a simple ramp would be the easiest and most economical solution. However the garage is small and a ramp with an appropriate slope would span halfway across the floor, leaving no room for a vehicle. A lift was designed to allow the client to go from his house to the garage and vice versa, while leaving enough room for a car to be stored in the garage.

SUMMARY OF IMPACT

The client will be able to move freely, easily, and safely between his garage and living quarters. His previous makeshift platform and ramp permitted him to get around, but it is not a very convenient setup. The design of this lift could be modified to fit the needs of other situations. For larger lifting ranges, larger sprockets could be used to further increase the power of the lift and longer crank arms used to accommodate the higher destination. This design may constitute a cheaper alternative for private ownership and small ranges.

TECHNICAL DESCRIPTION

The mechanism of the lift is simple, yet efficient and reliable. It uses four crank arms at each corner of the platform to lift or lower the passenger. The platform itself is 35 by 45 inches. It is made of $\frac{3}{4}$ -inch plywood supported by a frame of 1 $\frac{1}{2}$ by 1 $\frac{1}{2}$ -inch angle steel and 1 by $\frac{1}{8}$ -inch steel strap. The frame of the lift is made of 2 by 1 $\frac{1}{2}$ -inch angle steel, 1 by $\frac{1}{8}$ -inch steel strap, and 1 $\frac{1}{2}$ by $\frac{1}{2}$ -inch steel bar.

The power source of the lift is a 1/2 hp chain-driven garage door opener. The garage door opener was chosen because it already contains the electronics to be operated by remote control, and has an easily adjusted limiting switch and many safety features and checks. Its speed and lift capabilities are not appropriate for this application so both are changed by a double reduction gear train. The garage door opener turns an 8-tooth sprocket at 2 revolutions per second. This is linked by chain to a 60-tooth sprocket as the initial step of the gear train. Keyed to this 60-tooth sprocket is a 10-tooth sprocket that is linked by chain to another 60-tooth sprocket which, in turn, is connected to the lifting mechanism. This is the second stage of the gear train, after which the maximum lift force system is 375 lb. This 60-tooth sprocket is keyed to a 5/8-inch solid steel shaft that runs across the lift and is supported at either end by vertical 1 $\frac{1}{2}$ by $\frac{1}{2}$ -inch steel supports with bronze bearings. Also keyed to this shaft are two 24-tooth sprockets and two crank arms that lift the platform. The two 24-tooth sprockets are linked by chains that run down the sides of the lift to two similar 24-tooth sprockets attached by 5/8-inch shafts to the other two crank arms to lift the other end of the platform.

Most commercial lifts used for wheelchairs are designed for ranges between three feet and fifteen feet. Lifts cost thousands of dollars even for the smallest models. The material for the lift cost only \$420. The garage door used as the power source cost \$150. The collection of various sprockets and bearings cost \$245. The steel and plywood used for construction of the frame and platform cost \$25.



Figure 3.10. Wheelchair Lift

Hand Powered Tricycle

Designers: J. P. Adler, Daniel Batt, Timothy Phillips

Client Coordinators: Bonnie Cole

Handicapped Children's Association

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

The Handicapped Children's Association (HCA) requested an exercise and recreation device for children with limited or no use of their legs. A hand powered tricycle was already in use at HCA for this purpose, but its poor design and lack of adjustability made it unsuitable for their needs. Furthermore, it was not durable enough to withstand the rigors of use by dozens of children.

SUMMARY OF IMPACT

The design was intended to rectify the problems with the existing tricycle by modifying it or presenting an entirely new solution. The design was based on a tricycle platform. HCA criteria included durability, safety, proper fit to children, trunk and foot support, and simplicity of operation. The tricycle is very popular with the children and staff of HCA and is used almost continuously.

TECHNICAL DESCRIPTION

A commercial two-child foot-powered tricycle was modified. The benefits of this base tricycle included a good, low ride height, wide wheel track, long wheel-base, strong construction, and allowance for easy modification. From this base the foot cranks and the

forward seat were removed, and the handlebars and tubular structure were modified. A hand crank assembly and chain drive mechanism were designed to power the tricycle. Placement of the child was most crucial in conforming to design seat constraints. Of particular concern were the ease of turning and the powering of the tricycle with the same assembly. Although it is inherently difficult to meet these two criteria simultaneously the level of difficulty was reduced by adjusting the gear ratio and the geometry of the steering mechanism.

The final design features a hand crank assembly placed on the end of a moment arm support attached to the old handlebar mount. From that assembly, a chain runs down to the front drive wheel. The whole front fork assembly had its geometry changed to fit the measurements of what was considered an averaged size child for the HCA. A chain guard was fabricated to keep little fingers away from the chain and sprocket.

The total cost to buy the components and materials came to \$155. The cheapest commercially available model found by the authors was over \$370.



Figure 3.11. Hand Powered Tricycle

Pedal Car Modification

Designers: Sam Adeyinka, Michael Ferrari, Matthew Kmetz

Client Coordinators: Judy Zeamer

High Risk Birth Clinic

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

A vehicle was designed for a four-year-old child who has only partial use of his legs and right arm. Because of these constraints, the vehicle must be propelled, steered, and stopped solely by the client's left arm and hand. The solution was to motorize a commercially available pedal car.

SUMMARY OF IMPACT

The child's parents requested a vehicle that he can operate on his own. He had a pedal car, which he could not use. Although the car is ideally propelled by a child's legs and feet, the client does not have enough

leg strength, especially in a seated position, to accomplish this.

With this design, the vehicle is powered, steered, and stopped purely by the left arm and hand. Power from the motor enables the child to use the car for long lengths of time without tiring himself. The child will also be able to maneuver the vehicle easily over many different types of terrain. The electric motor limits the speed of the car and can even be used for braking, ensuring added safety. It also allows the child to use primarily his left hand to steer the vehicle.

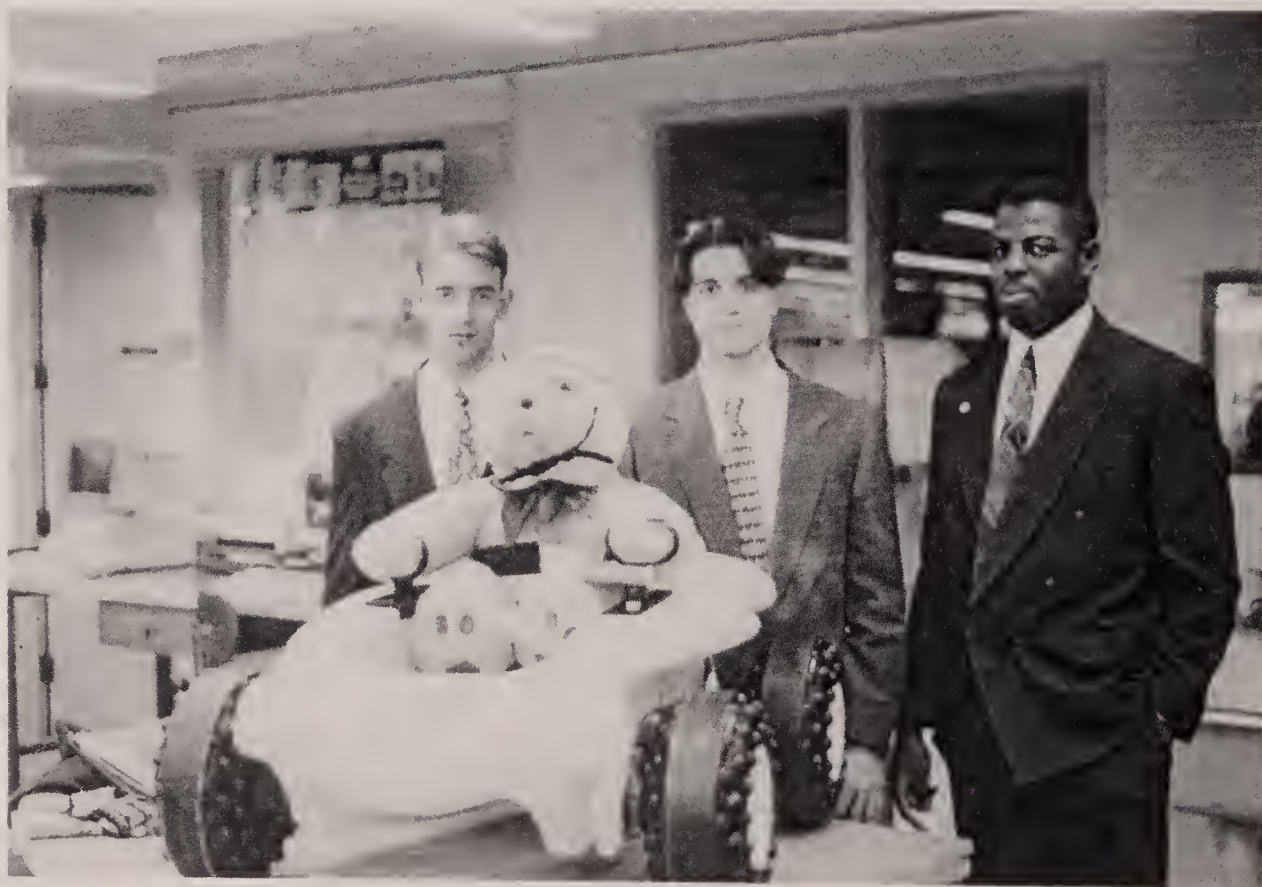


Figure 3.12. Modified Pedal Car.

TECHNICAL DESCRIPTION

The car selected for this project is manufactured by the Little Tykes company. The pedals were removed from the vehicle and the bottom of the car was closed up to give the client a place to rest his feet and secure his legs. A 12 volt motor and gear box purchased from Power Wheels are attached to each of the front wheels. Wire is run from the motors, through the batteries, and into a switch that is installed on the left handle of the car. The switch selected is from a power window in an automobile. The switch is wired so that, when pressed in one direction, the car goes forward and, when pressed in the other direction, the car goes in reverse. When the button is released it snaps back to the neutral position and the motors come

slowly to a halt. The wire is also run through a kill switch under the seat of the vehicle. The connection is made when someone sits down on the seat and is broken when the person stands up, so the client cannot accidentally start the car if he is standing up. A Velcro seat belt was also added for safety. The steering mechanism was modified slightly in an attempt to make it easier for the client to maneuver the vehicle. A thrust bearing was added under the steering bar where plastic and metal had been rubbing against each other.

The final cost of this project was \$278.

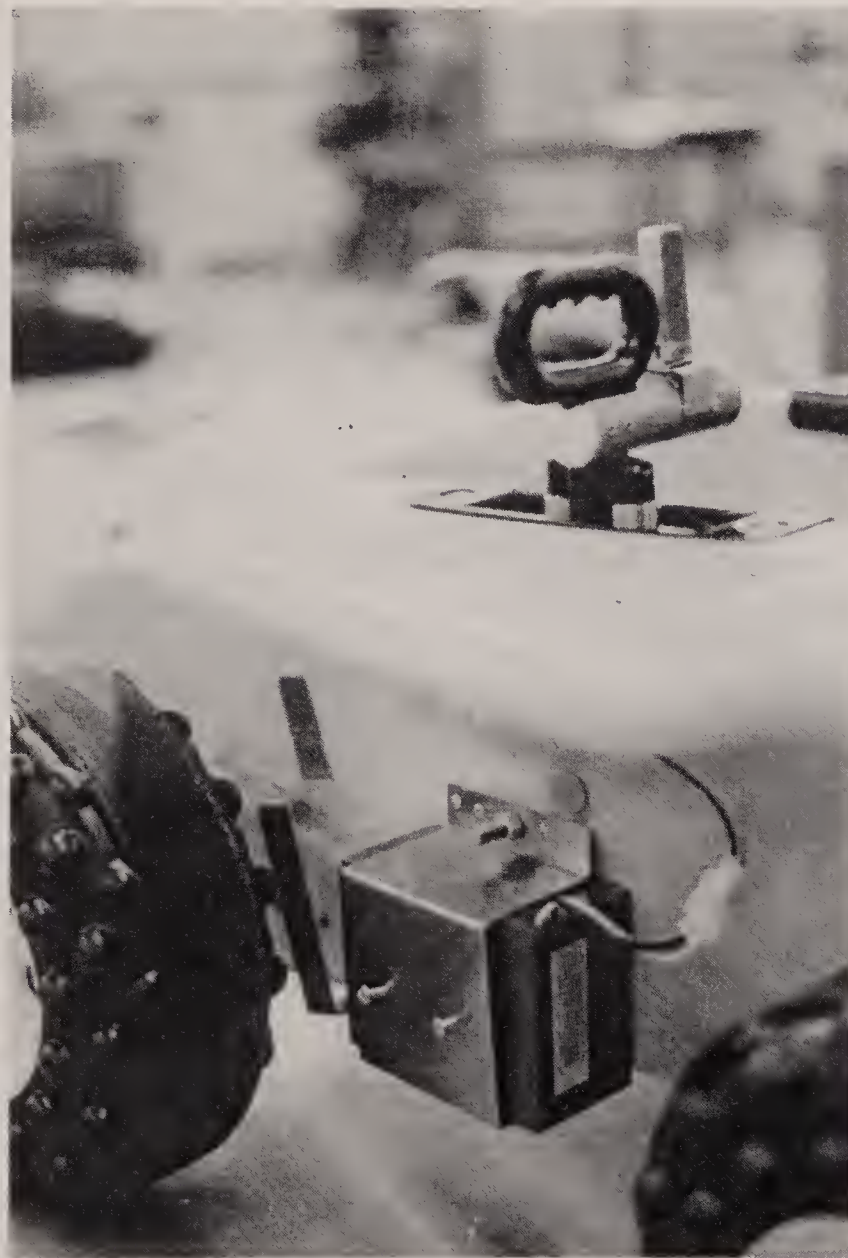


Figure 3.13. Close-Up of Motor and Handle.

Bicycle Trailer

Designers: William Grivas, Michael Miele, Anthony Tyska

Client Coordinators: Judy Zeamer

High Risk Birth Clinic

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

The purpose of the system is to allow the parents of a child with quadriplegia to bring their child along for a bicycle ride. The overall system is light enough and compact enough to be pulled by a bicycle. The system is also comfortable for the client.

SUMMARY OF IMPACT

The client has no control of any major muscles. Typical bicycle configurations preclude her ability to ac-

company her parents on a bicycle ride. The challenge in this design project was to allow the client to enjoy a normal bicycle ride in comfortable and safe positions. Models already available were expensive and did not permit the client to relax in a comfortable position.

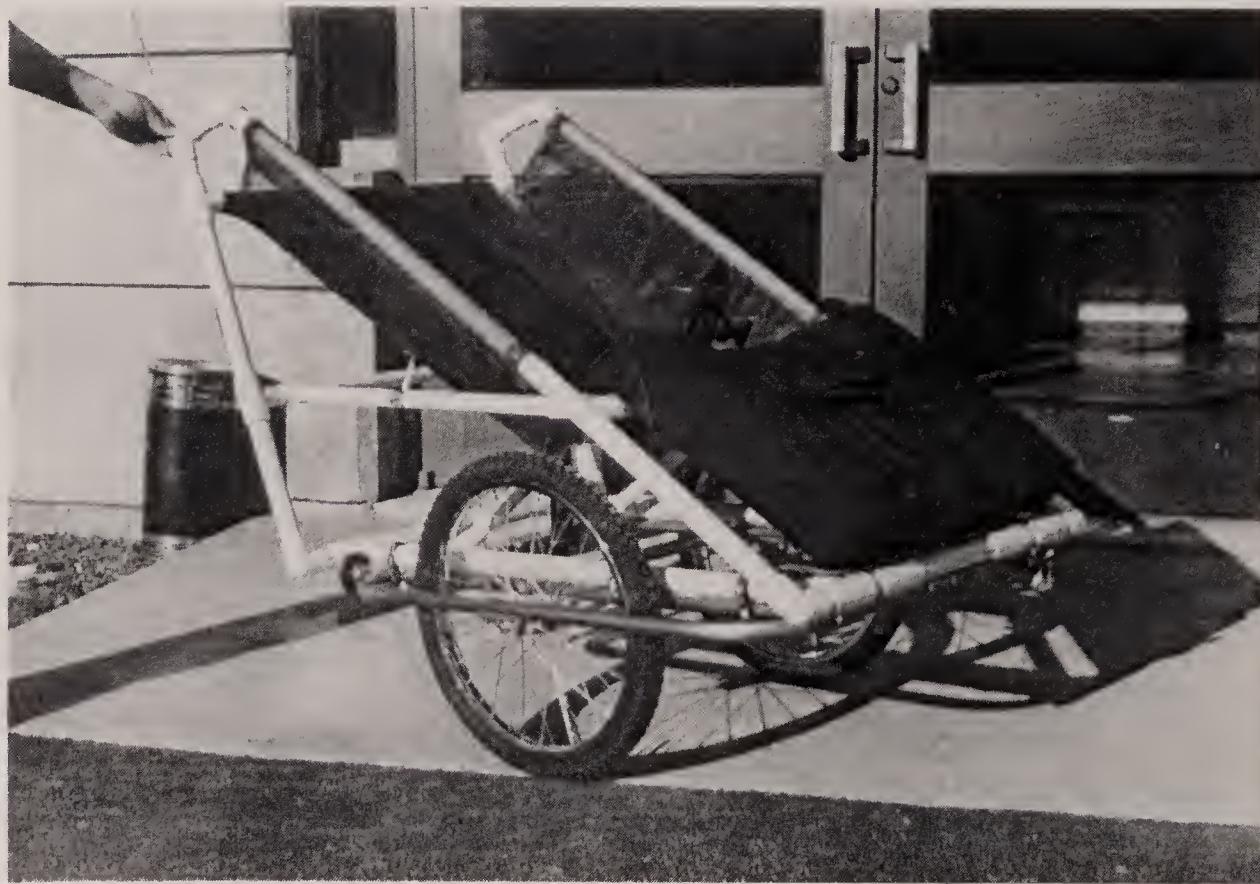


Figure 3.14. Bicycle Trailer.

TECHNICAL DESCRIPTION

The final design entails a commercial bicycle trailer frame. 20-inch off road tires on standard wheels are incorporated to add support and stability, and to supply smoother ride characteristics (due to a wider surface contact area than standard tires). PVC supports are added at critical locations of the chair frame structure to reinforce sections directly attached to the sling seat holding the client.

The trailer frame customizer kit that was acquired from Equinox Industries of Cottage Grove, Oregon was easily modified. The aluminum frame design allows for easy incorporation of the chair support structure using a three-step procedure. First, the seat structure is drilled to allow the four mounting pins on the aluminum frame to be inserted into the PVC base. Second, a bead of adhesive silicone caulking is sandwiched between the chair structure and the aluminum frame. Finally, six adjustable hose clamps are used to completely secure the two pieces into one unit. PVC reinforcement bars are then added at the maximum shear and bending points.

The maximum dimensions of the constructed system are as follows: 42 inches in length, 31 inches in width, and 31 inches in height. The manufacturer's stated capacity for the aluminum base is 150 pounds. The

PVC structure has been laboratory tested with these loads and there is no problem when such a load is placed on the structure. The client weighs only 47 pounds; therefore, this system has a minimum safety factor of three. The overall weight of the system when unoccupied is approximately 45 to 50 pounds.

A stress analysis was performed on several parts of the PVC structure when loaded with 50 pounds (the approximate weight of the client). The analysis indicated that that no one part of the system is under an amount of stress that would pose a danger to the client. For example, the pipe under the seat that is in compression has a normal stress of about 15.8 psi, and a shear stress of approximately 6900 psi. These calculated values are significantly less than the yield stress values for the material, and as a result, are deemed to be at safe levels.

Many additional features were added to the system ensure the client's safety. Velcro straps and buckles are added on the Cordura seat to keep the client in a safe position. The footrest is padded and straps are sewn on to prevent major movement of the client's legs. In order to increase visibility in the evening, reflectors were added to the back end of the system. Finally, a universal joint connects to the bicycle to prevent any possible overturning of the system. The final cost for the system was \$371.

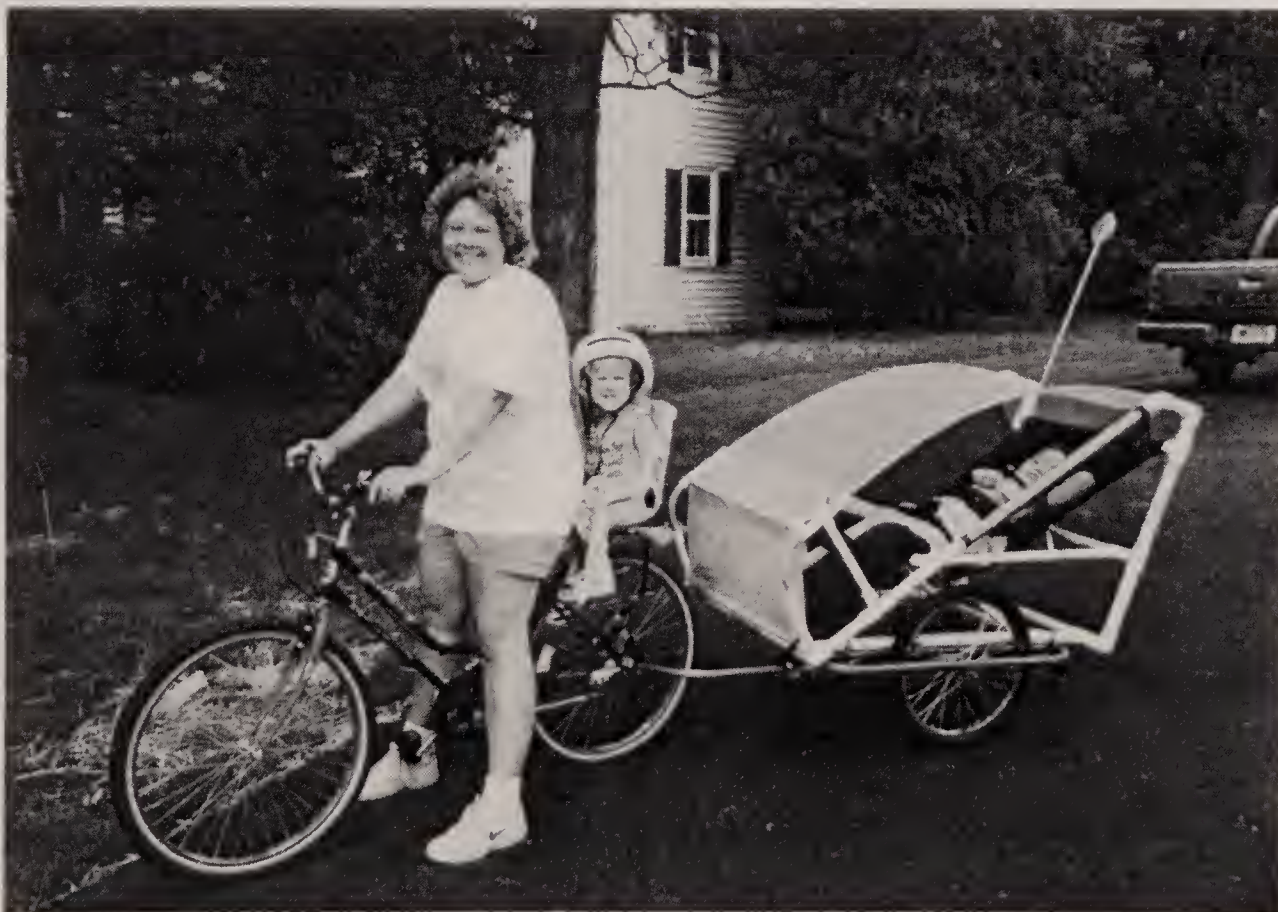


Figure 3.15. Trailer Attached to Bicycle

Wheelchair Table

Designers: Juan Alvarez, Matthias Reith, Karen Zhang

Client Coordinators: Eric Lopez

Binghamton University

Supervising Professor: Richard Culver, Ph.D.

Department of Mechanical Engineering

Binghamton University

Binghamton, NY 13902-6000

INTRODUCTION

A college student confined to a wheelchair had difficulties using the regular classroom tables and desks provided by Binghamton University. Although the university distributes specialized desks for individuals with handicaps, the client finds their availability and usefulness unsatisfactory. He requested a device upon which he can work and write.

SUMMARY OF IMPACT

Nothing presently on the market adequately suits the client's needs. Most available trays require wheelchairs with armrests or are situated on the person's lap; both scenarios were considered inadequate for the client. The design chosen consists of a detachable table and ball joint with an adjustable support rod. It provides the adequate size and portability the client demands.

Overall, the needs of the client have been met through the design and assembly of the final device. The final accessory table is highlighted with the rotational and adaptable qualities he requested. This device was designed based upon the geometry of the wheelchair as well as the needs of the client. Due to the complexity and wide variety found in the geometry of wheelchairs, it would be rather difficult to standardize most of the parts in the final device.



Figure 3.16. Client with Wheelchair Table.

TECHNICAL DESCRIPTION

A low profile vise that includes a ball joint is used to add rigidity to the support of the system. The vise attaches to a small plate of acrylic that is bonded to an acrylic tabletop. In order to increase the stability of the table, machined aluminum parts are attached to the chair's support bars. A telescoping music stand serves as a support rod, which allows for displacement of the table in a vertical direction.

As with any device manufactured for use in public, this table must protect the client and others from harm. In the evaluation of the safety of the design, the weight, geometry, and the durability of the table were

considered. This table is assembled to handle minimal loads up to 20 pounds, well above any load applied in the client's daily use of the device. An aluminum support rod with a one-inch diameter provides the desired stability. The support rod connects to the table near the centroid of the rectangular tabletop, thus resulting in a small moment arm to any applied loads. The rigid attachment of the aluminum connection joints adds to the stability of the device.

The final device came to a cost of \$87, well below the cost of similar products on the market that usually range above \$200.

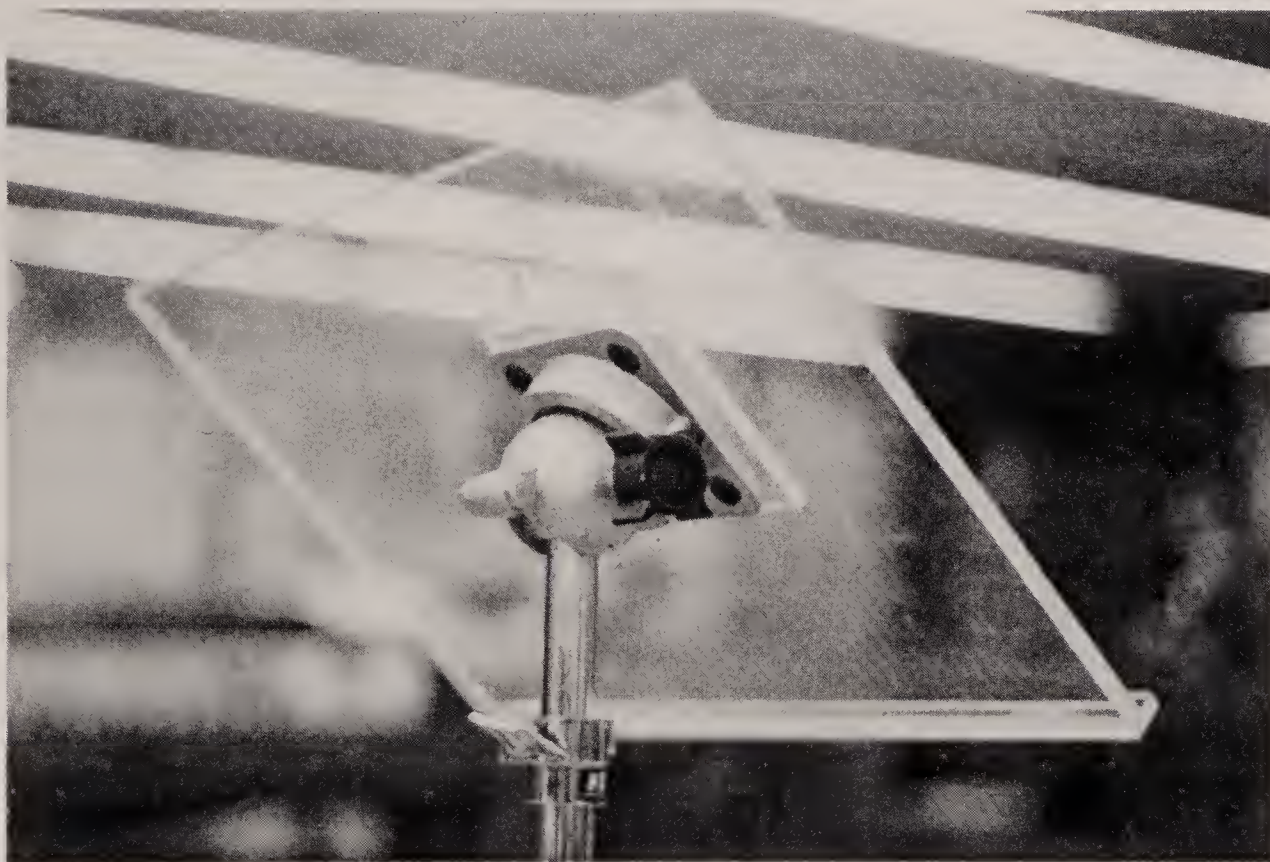


Figure 3.17. Close Up of Wheelchair Table



CHAPTER 4

MANHATTAN COLLEGE

**School of Engineering
Mechanical Engineering Department
Riverdale, NY 10471**

Principal Investigator:

*Daniel W. Haines (718) 862-7145
dhaines@mcs1.rlc.mancol.edu*

Light Interaction Board

Designers: Marc Mauro, Peter Sawicki, Chris Shuler

Client Coordinators: Anjum Lome and Dan Schipf, Brandywine Nursing Home, Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

Some stroke victims can be helped by therapy that includes exercises in eye/hand coordination. Light interaction boards are devices that incorporate the matching of colored lights and geometric shapes. Typically, a therapist poses a geometric form or color and the patient attempts to indicate recognition by matching the required aspects by means within the capability of the patient.

SUMMARY OF IMPACT

Anjum Lome, an occupational therapist at Brandywine Nursing Home, requested a light interaction board for use with her patients. She gave the initial specifications and contributed criticisms as the project evolved. She is pleased with the outcome.



Figure 4.1. Photograph of the Light Interaction Board.

TECHNICAL DESCRIPTION

The product is composed of three components: 1) the display board, a large wall-mounted board containing the assortment of colored lights and shapes; 2) the patient response board, a desk top board with the pattern that matches the wall-mounted board used by the patient; and 3) the control panel used by the therapist. Twenty-two shapes consist of stars and circles and five colors range from red to purple. These three ele-

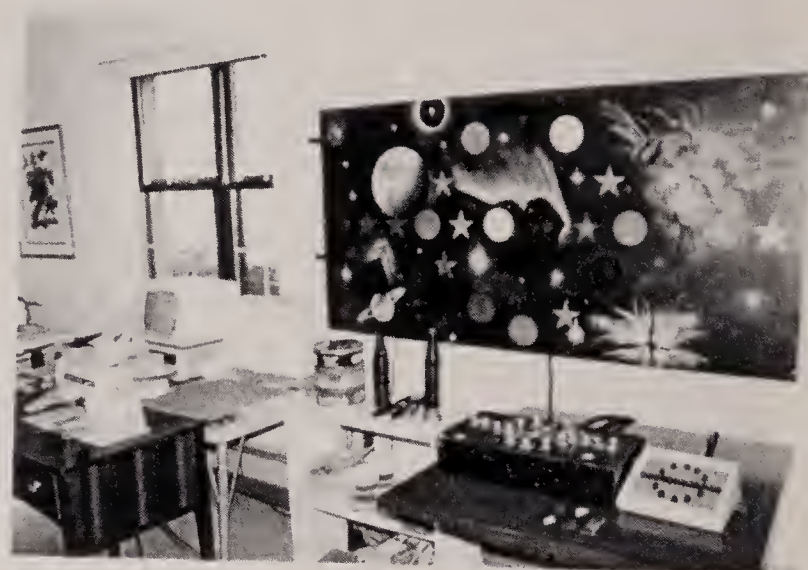


Figure 4.2. Light Interaction Board after Installation on the Wall.

ments are shown in the background and in the hands of the designers in Figure 4.1.

Figure 4.2 shows the Light Interaction Board after installation on the wall of the Brandywine recreation room. The cables that connect the patient response board with the control panel are sufficiently long that they can be located as desired for convenience.

Figure 4.3 shows a schematic of the circuit for the elements. The front panel of the display board is $\frac{1}{4}$ -inch thick pressboard. The back panel is a $\frac{5}{8}$ -inch thick sheet of particleboard. The frame is constructed of red oak. The inside of the display board is made accessible by the use of studs and wing nuts. The display board lights were attached inside the frame and covered with shapes of varied colored Plexiglas. The lights were placed inside silver cups and spray painted silver, so that the light bulbs reflect as much light as possible. The cups also confined the light so that no lights other than that intended are illuminated. The front panel is painted black to ensure that the lights are easily seen. The black color did not please all involved, but this problem was resolved through the artistic talents of one of the designers. It was

agreed to regard the black field as representing outer space. Solar systems, consisting of planets and stars were painted on the board. The outcome delighted all.

The patient response board was constructed of the same wood as the display board. The switches were mounted inside the box below the top sheet of wood. The wires were connected to the switches. This board was then mounted inside the box with all wires protected. Holes were drilled in the top to match the location of the switches. This was a critical step in order for a peg placed in the hole by the patient to match the button below. These pegs are 1.25 inches in diameter and 2 inches long. The patient response board is painted to match the display board. The switches are single pole, single throw and momentary push button that are normally closed. Until the switch is pressed, there is a constant flow of electricity. If the patient places a peg in the wrong hole, nothing happens. However, if a patient places a peg in the correct hole, the corresponding light goes off. Figure 4.4 shows some detail of the patient response board.

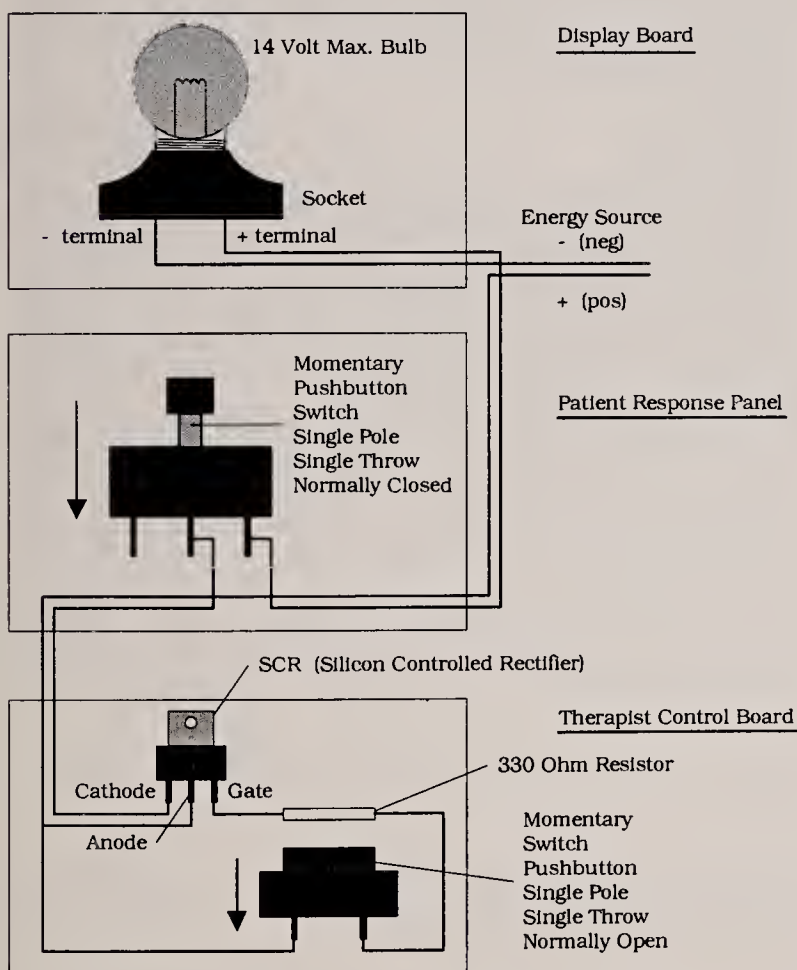


Figure 4.3. Schematic of Circuit for the Light Interaction Board.

The control panel enables the therapist to turn on as many lights as he or she wishes within the range of one to 12. The control panel was purchased from Radio Shack. The power source is a 12 volt battery. This panel has single pole, single throw, normally open push-button switches. These switches are positioned in the same pattern as the display board. Silicon controlled rectifiers (SCR) were incorporated in the circuits to allow lights to be illuminated only by the therapist. The SCR acts as a gate. When the therapist's switch is pressed, the gate closes and the circuit is closed. Since the gate has a nine-volt limit, a 330 ohm resistor was placed in the line. When the patient presses the correct switch a pulse sent to the SCR opens the gate. This breaks the loop and shuts off the light. Figure 4.4 shows some detail of the control panel.

The cost of the Light Interaction Board is \$412.

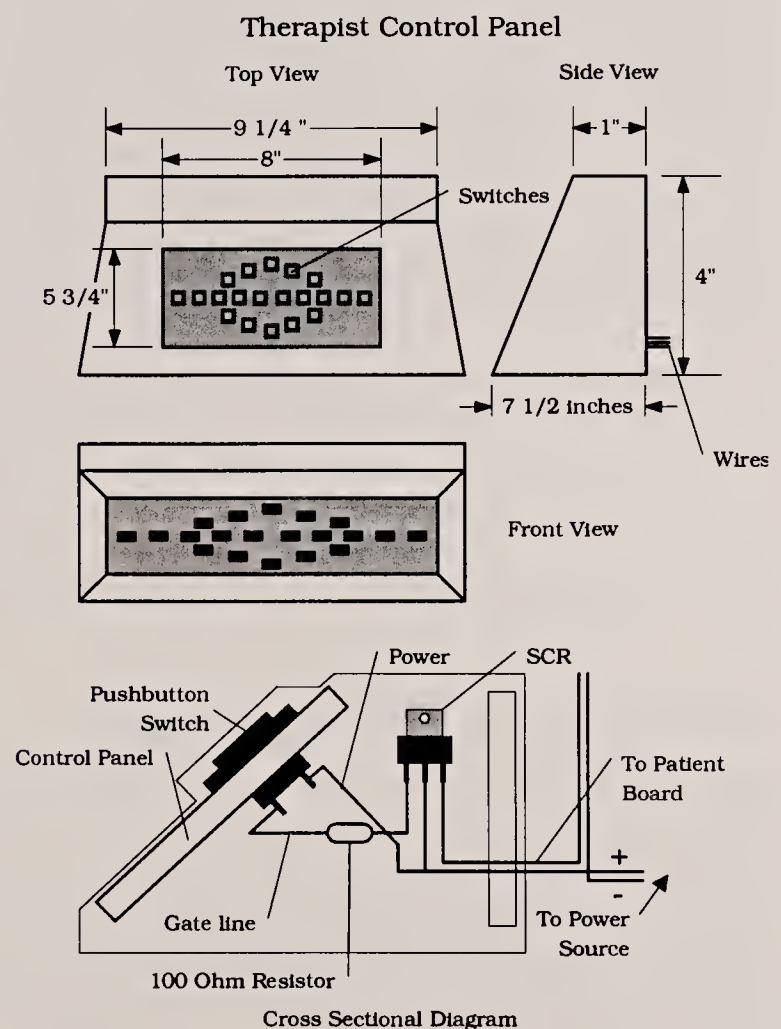


Figure 4.4. Details of the Control Panel.

Up 'N Down Adjustable Table

Designers: Chris Cantelmi, Eugene Hundertmark, Peter Slater

Client Coordinators: Susan Holmes, OT, Dan Schipf

Brandywine Nursing Home, Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

People who were once active gardeners, but have suffered a physical disability, can receive great satisfaction by resuming activities such as setting plants in soil and trimming and watering plants. Susan Holmes, a horticultural therapist at Brandywine Nursing Home, requested a custom-built table with specific dimensions and adjustments for the greenhouse.

SUMMARY OF IMPACT

Wheelchairs are of varied heights. The tables in the Brandywine greenhouse are fine for use with small wheelchairs; however in order for residents in large wheelchairs to use the tables, the tables had to be raised by stacking books beneath them. A table with adjustable height was preferable. The table had to have wheels so that it could be placed in the desired position by Ms. Holmes and so that the residents did not have to maneuver around it in their wheelchairs. Finally, the table had accommodated all wheelchairs. The adjustable Up 'N Down table was the result, and it is now in regular use in the Brandywine greenhouse. It has provided all of the functions requested by the coordinator.

TECHNICAL DESCRIPTION

Figure 4.5 shows the three designers standing behind the Up 'N Down table. The adjustable table is based on a C-shaped frame of aluminum square tubing. The connections are welded, rather than bolted, for greater strength. In order to provide adjustability, the lower section of each leg is constructed of one-inch (nom.) tubing and the upper portion of each leg is constructed of $\frac{3}{4}$ -inch tubing. This allowed the upper part of the leg to slide in and out of the lower half, creating a telescoping motion. The legs have gussets welded to the joints for additional strength. The legs are joined by two cross bars, one at the base and an-



Figure 4.5. Photograph of the Up 'N Down Adjustable Table.

other about midway up from the base. A side view of the table is seen in Figure 4.6.

To provide the means to adjust the table height, a Fulton marine trailer jack was chosen. The jack originally had a single wheel at the bottom and a hinge on the side, but these were removed, leaving only the crank and shaft. The bottom of the jack is bolted to the cross bar on the legs. The cap at the top of the jack is screwed to the underside of the table. The jack,

when cranked, can provide a 9.5-inch range of vertical motion. A clamp that fit around the jack cylinder was bolted to triangular braces that were in turn bolted to the back of the legs. This system was installed to ensure that the table remained horizontal as the height was adjusted. The bracing system, jack and crank are shown in Figure 4.7.

The dimensions of the table top, 32 by 19 inches, were determined by Susan Holmes. The top is a store-bought Formica-laminated wood panel, cut to the specified size. The corners are rounded and black

rubber molding is glued along the edges. Plastic stoppers are placed in the tube ends to prevent harm to the residents. Stock wheels were obtained and attached to the legs. The frame is painted greenhouse green.

Cost of materials is \$200.

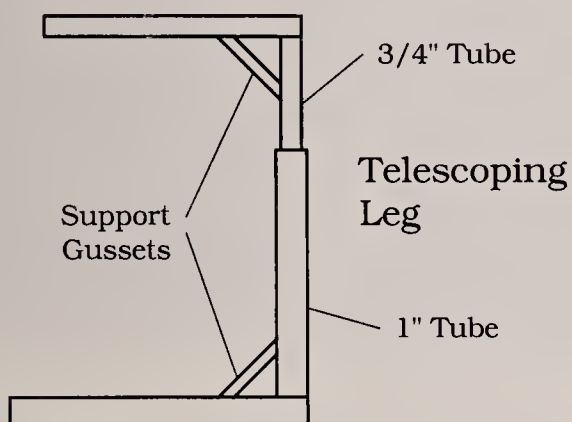


Figure 4.6. Side View Mechanical Drawing of the Up 'N Down Adjustable Table.



Figure 4.7. Another view of the Up 'N Down Adjustable Table.

Skill Saver Busyboard

*Designers: Joseph DeNivo, Jennifer Nold, Peter Murphy
Client Coordinators: Laura Meza, OT, Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471*

INTRODUCTION

Busyboards are panels on which everyday objects are fixed; they serve to stimulate and amuse people with limited skills. Design considerations required that it have:

- smooth edges
- padded surfaces
- securely fastened elements
- multiple and interchangeable boards
- removal provision positioned low to the base
- no loose objects

and be:

- lightweight (less than 20 pounds)
- durable
- capable of being securely fastened to a wheelchair

and provide:

- practice of typical daily skills
- sense of satisfaction
- challenge

SUMMARY OF IMPACT

The Skill Saver Busyboard meets the requirements above and is in regular use at Brandywine Nursing Home. It provides the anticipated activity for those in need of its features.

TECHNICAL DESCRIPTION

The Skill Saver Busyboard is comprised of two boards, each with a set of objects. The two boards fit in a frame and are interchangeable. The center board shown in Figure 4.8 shows the Skill Saver Busyboard with Board 1 in place. Board 2 is shown to the right. The three individuals are the designers.

The busyboard is framed with one by two-inch poplar, forming a rectangle 21 inches high and 20 inches wide. On the inside surface of the frame, a channel was cut $\frac{1}{2}$ inch wide by $\frac{3}{8}$ inch deep, and the frame



Figure 4.8. Skill Saver Busyboard.

can be opened from the side to accommodate the interchangeable boards. The base is an 8 by 18 inch piece of birch, $\frac{1}{2}$ inch thick mounted on two feet of poplar. The frame weighs four pounds 12 ounces without the busyboard in place, which is light enough for the staff to move and mount to the wheelchairs.

The two interchangeable boards are constructed of $\frac{1}{2}$ -inch thick plywood with dimensions of 18 by 20 inches. All edges were beveled in order to slide the boards into the frame.

The components of Board 1 permit a variety of manipulations: the slide locks allow for linear motion; the key lock provides rotational motion along with the opportunity to manipulate small objects; the door knob and mechanical valve present opportunities for rotational motion at different angles. A drawing of Board 1 is shown in Figure 4.9.

Board 2 contains cabinet doors that require a pulling motion, light switches that require a force in two directions, and a shoelace that requires a threading motion and dexterity in tying a bow. The flashlight bulbs operated by the switches are powered by two AA

batteries accessible from the back of the board. A drawing of Board 2 is shown in Figure 4.10.

The cost of materials for the Skill Saver Busyboard is \$200

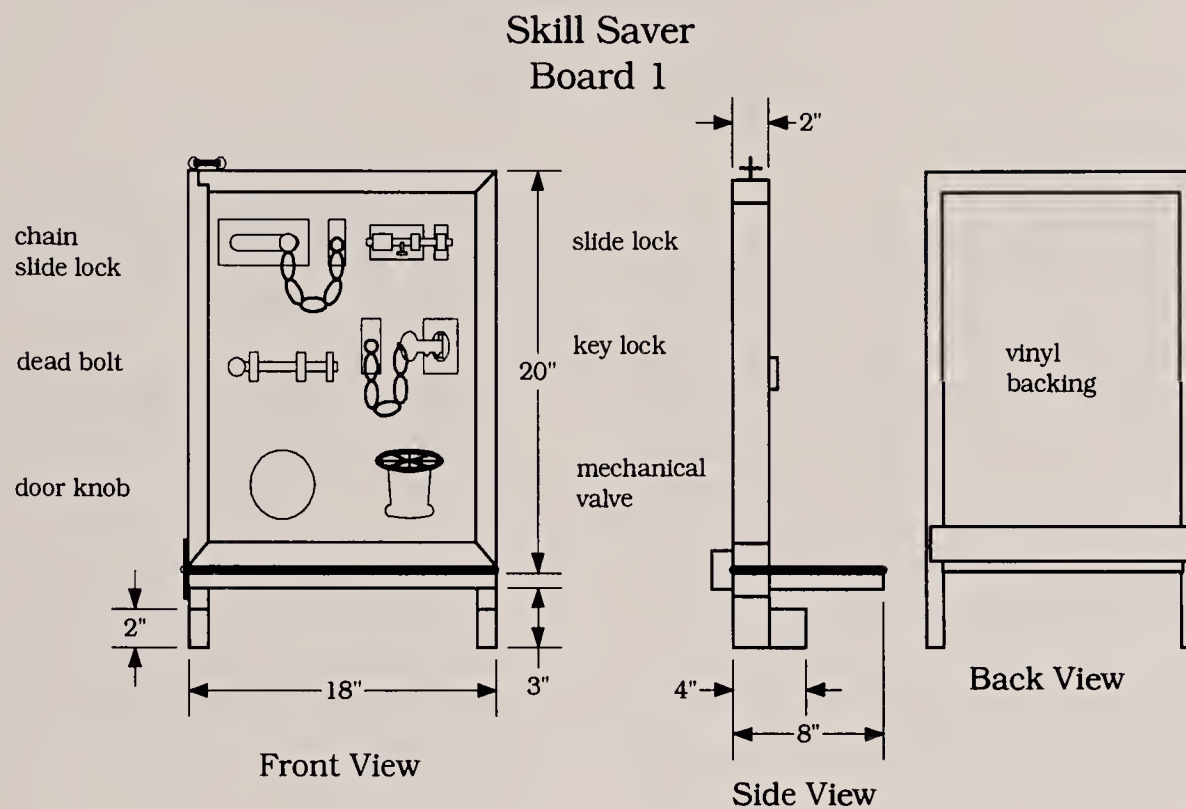


Figure 4.9. Drawing of Board 1.

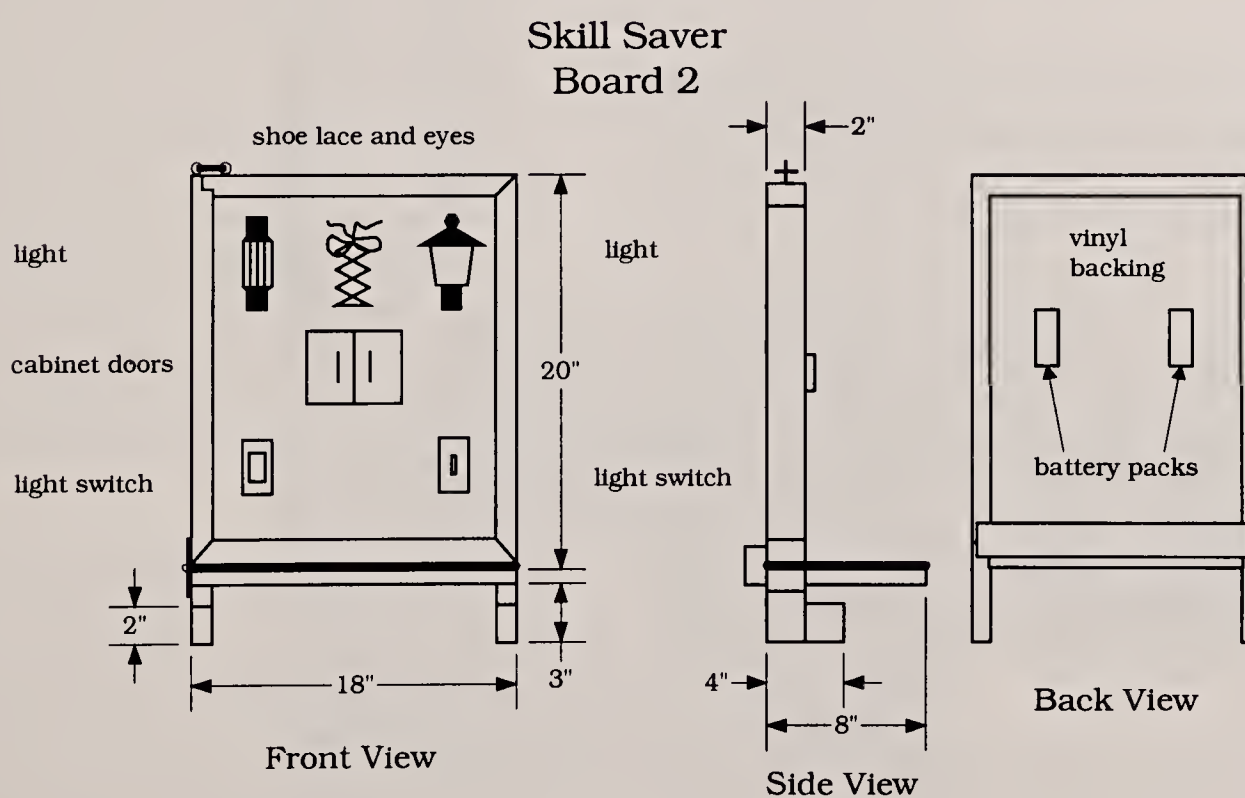


Figure 4.10 Drawing of Board 2.

GEO on the Go

Designers: Christina Curry, Richard Eskew, Katherine Giles
Client Coordinators: Margaret Mann, PTR, Anjum Lome, OT, Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471

INTRODUCTION

People who have experienced a stroke or have a brain injury tend to lose their motor coordination and their ability to grasp objects. In order to relearn such abilities, a puzzle board with various shapes and colors to match proves helpful to the therapist. Margaret Mann, a physical therapist at Brandywine Nursing Home, knew of certain products available for purchase, but none that met the particular requirements she had in mind. She requested a board that could be mounted on the wall and adjusted in height. The puzzles would optimally have elements with a variety of sizes and shapes. The GEO Puzzle was designed and constructed to meet her request.

After working with the GEO Puzzle for a year, Margaret Mann requested that the mechanism be motorized. This was accomplished with a system operated by push buttons. The GEO on the Go is the successful result.



Figure 4.11. GEO on the Go.

SUMMARY OF IMPACT

The GEO on the Go is mounted on the wall in the recreation room of the Brandywine Nursing Home. It has proved to be a useful and needed enhancement to

the original GEO Puzzle. Therapists Margaret Mann and Anjum Lome use it with one or more residents on nearly a daily basis.

TECHNICAL DESCRIPTION

Figure 4.11 shows the three designers with the Geo on the Go.

Vertical motion of the Geo Puzzle is now provided by means of a one inch diameter power screw, 4-1/2 feet long with four threads per inch. It is mounted at the top with a simple wood block and at the bottom with a lubricated pillow block that decreases the friction of the turning screw. The ball bearing nut that travels on the screw is encased in a wooden housing that is attached to the Geo Puzzle by a piano hinge.

The screw is powered by a 200 rpm brush motor operated by a three-way toggle switch under the motor housing. In the neutral position the motor is off. The board moves down when the switch is moved towards the wall and up when moved toward the therapist. Green LEDs on the side of the motor casing indicate the direction of board movement. Limit switches are at the top and bottom of the range of movement of the board. Red LEDs on the side of the motor casing are illuminated when the limits have been reached. These limits prevent the screw from jamming when the ball reaches the extreme positions. The detailed schematic of the circuitry is presented in Figure 4.12.

To engage the table function for use by a patient, the board is lowered to a low position. The bottom of the board is then pulled out while the top pivots on the piano hinge. Support legs, which are attached to the back of the board, are then swung into position and the board is in position for use by the patient. This position is represented in Figure 4.13.

The cost of the Geo on the Go is \$306.

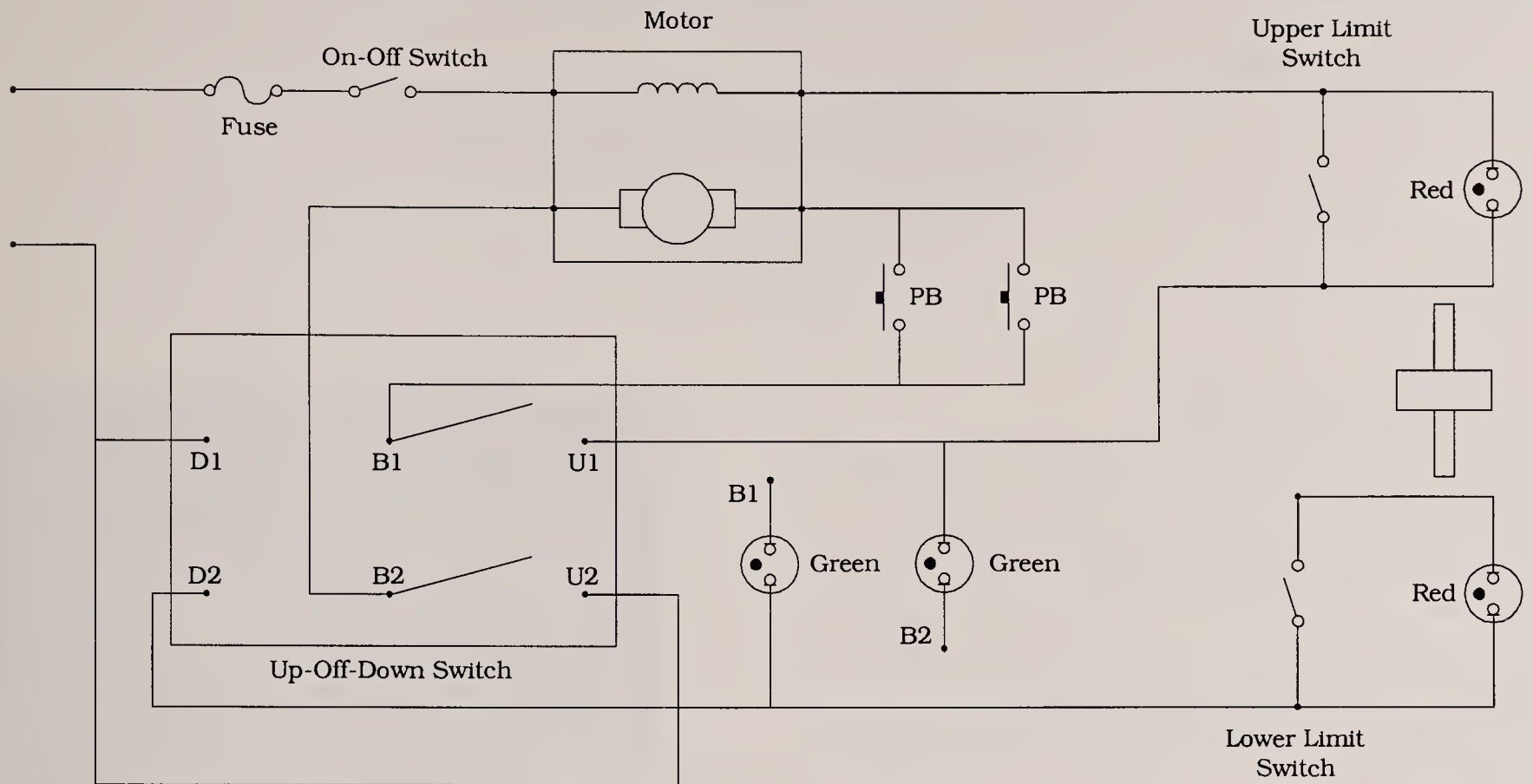


Figure 4.12. Detailed Schematic of the Circuitry for GEO on the Go.

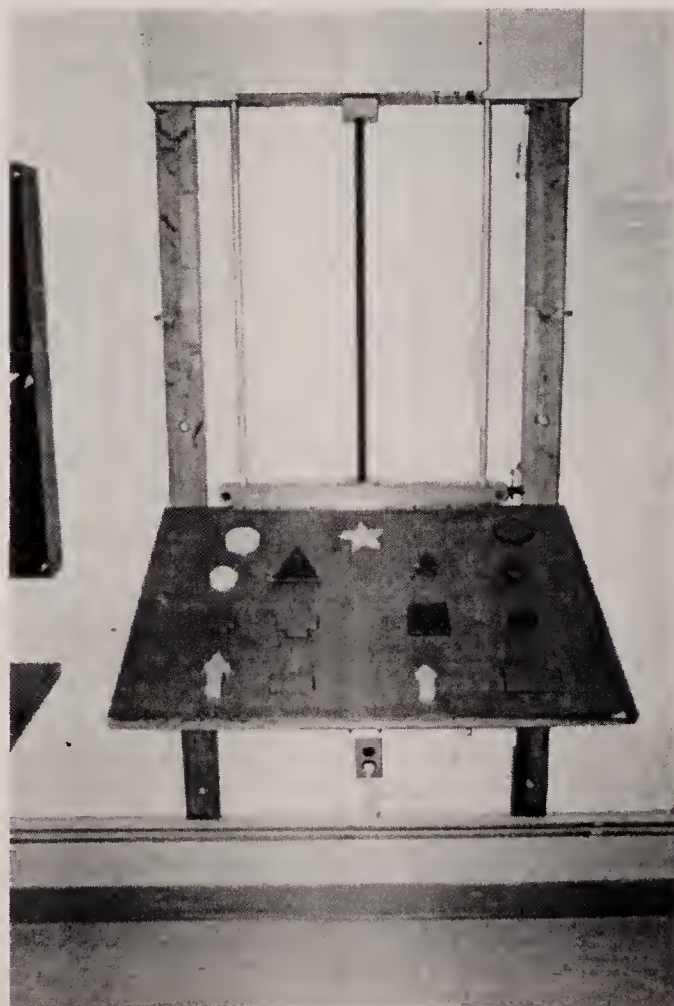


Figure 4.13. Another View of GEO on the Go.

ADL Busyboard

*Designers: Lee Pavone, Jeffrey Shutz
Client Coordinators: Laura Meza, OT, Dan Schipf
Brandywine Nursing Home, Briarcliff Manor, NY
Supervising Professor: Dr. Daniel W. Haines
Mechanical Engineering Department
Manhattan College
Riverdale, NY 10471*

INTRODUCTION

The basic requirements for busyboards are discussed earlier in the section on the Skill Saver Busyboard. In this case Laura Meza, an occupational therapist, requested one for residents when working at a table. The term "ADL" stands for "activities of daily living."

SUMMARY OF IMPACT

The ADL Busy Board is in everyday use at the Brandywine Nursing Home.



Figure 4.14. ADL Busy Board.

TECHNICAL DESCRIPTION

Given that the ADL busyboard is to be used on a table surface, a wider space was provided to enable two panels to be mounted simultaneously. In order to provide greater variety, a third panel is available with different objects mounted on it. The three panels are interchangeable. Figure 14 shows the three panels on display, held by the two designers. The ADL busyboard with two panels in place is at the right.



Figure 4.15. Another View of the ADL Busy Board.

Another view of all components is shown in Figure 4.15.

Items selected for use in this busyboard included a kitchen faucet, and the items were mounted on two panels to provide variety. The ADL busyboard is 30 inches high and 22 inches wide. The objects are mounted on two panels each of $\frac{1}{2}$ -inch plywood, 21 inches high, 13.5 inches wide. For the panels to fit and be installed conveniently, slots were created in the side rails of the frame by dado cuts. The slots are $\frac{1}{2}$ inch wide by $\frac{3}{8}$ inch deep.

Figure 16 shows the dimensions of the frame of the ADL busyboard.

The cost of materials for the ADL busyboard is \$169.

ADL Busyboard

Frame Layout

- All dimensions in 1" Oak wood board
- Glued and nailed
- All edges are rounded

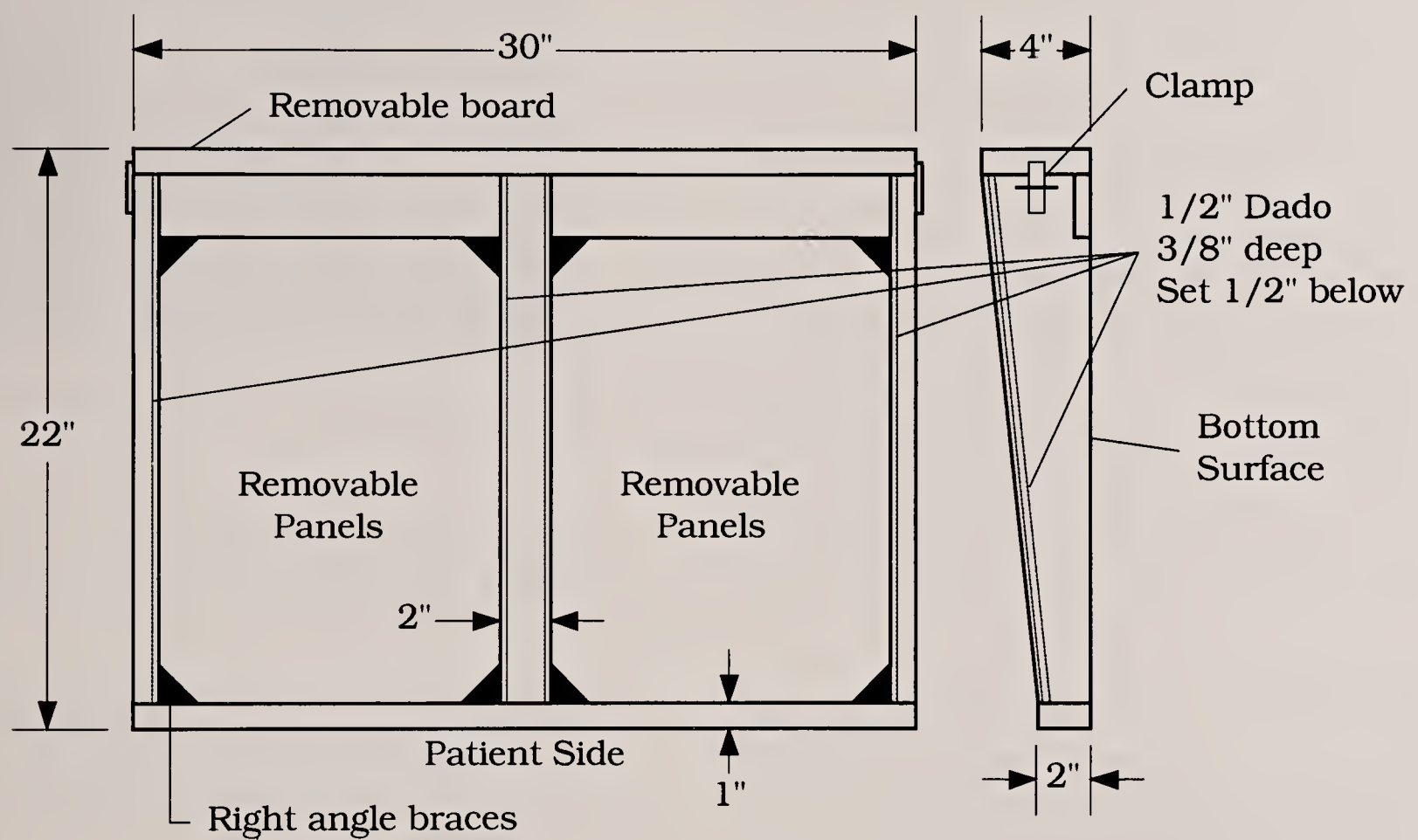


Figure 4.16. Mechanical Details of the ADL Busyboard

Repairs and Enhancements of Mr. Shifter and the Voice Activation of System of Waterworks III

Designers: Patrick Gordon, Alfred Nagib, Robert Kostadina

Client Coordinators: Susan Holmes, OT, Dan Schipf

Brandywine Nursing Home, Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

Mr. Shifter

Some gardeners with disabilities have difficulty handling the tools to transfer soil to a pot. Susan Holmes, OT at Brandywine Nursing Home requested a means to enable such people to perform a meaningful task related to the need. It was determined that if the gardener could operate the controls to transfer soil from a hopper to the pot, that contribution would be significant. The product produced by the designers is Mr. Shifter, a machine that contains at the base of the hopper an opening that allows soil to drop through and be received by a horizontal rotating auger. The rotating auger carries the soil horizontally to be deposited in the flowerpot. The auger is turned by an electric motor that is controlled by adapted switches developed previously for such projects as Waterworks. As original delivered the previous year, the motor operated under severe strain and the device vibrated excessively. The designers undertook the task of resolving these problems.

Waterworks III

Waterworks is a series of products developed for Brandywine to water plants. As its name indicates, Waterworks III is the third generation of this series, developed in the spring term of 1995. Its distinctive enhancement is a system of voice activation for use by residents with severe limitations of hand dexterity. During the summer of 1995, it was reported to us that the voice activation had ceased to operate.

SUMMARY OF IMPACT

As delivered in 1995, Mr. Shifter transferred soil only at the highest speed. The reduced speed range under load was determined to be a result of friction and path of soil transfer, two factors that had been underesti-



Figure 4.17. Photograph of Repairs and Enhancements of Mr. Shifter and the voice activation of system of Waterworks III.

mated. In addition, the unit vibrated excessively and was extremely noisy. Both of these problems have been resolved and Mr. Shifter is now a valued addition to the greenhouse.

The designers found that the reported problem with Waterworks III could be solved by simply replacing a drained battery in the circuit. However, they undertook a program to aid future investigations should more problems occur with the voice activation unit.

TECHNICAL DESCRIPTION

Figure 4.17 shows the repaired and enhanced Mr. Shifter, the voice activation system of Waterworks III, and its three designers. In the hand of the Patrick Gordon, the central figure, is the microphone for Waterworks III. These elements of the two projects are shown together since the voice activation is a versatile switching unit and can operate Mr. Shifter as well as Waterworks III.

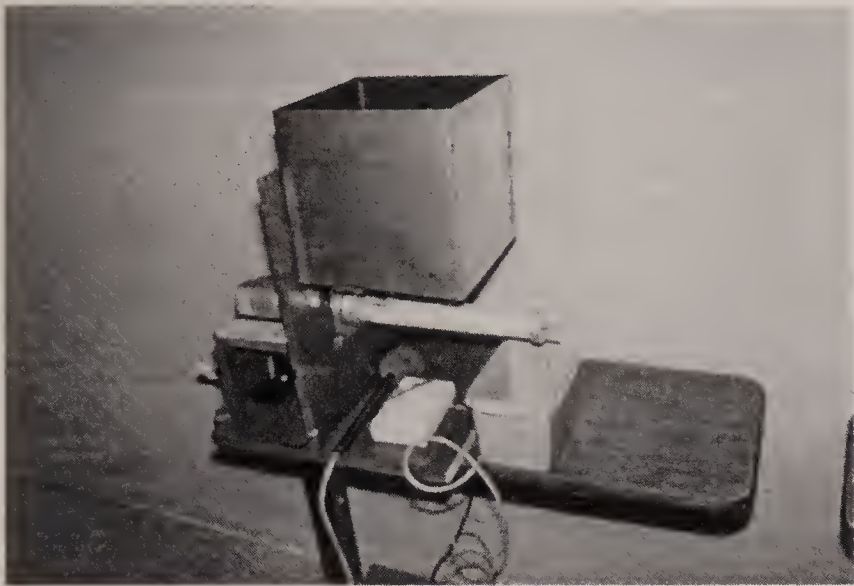


Figure 4.18. The New Mr. Shifter.

The friction problem of Mr. Shifter was resolved by replacing the original 1-inch diameter pipe with a larger 1.25-inch diameter PVC pipe. Also, the slope to the entrance to the auger was altered to allow the soil to settle into the teeth. The vibration problem was nearly eliminated by this modification, and the noise level was made fully satisfactory by the addition of DynaMat vibration damping material to the panels of the bin.

The new Mr. Shifter is shown close-up in Figure 4.18. Visible is the new 1.25-inch white, horizontal, PVC pipe that serves to conduct the soil from the bottom of the bin to the end of the pipe where it drops into the pail.

Also in the photograph are the essential elements of Waterworks III, the white case containing the circuitry and the microphone with its decorative flower.

As part of the project, the designers developed a diagnostic flow chart in order to aid future project designers to trouble shoot the voice activation system. This flow chart is shown in Figure 4.19.

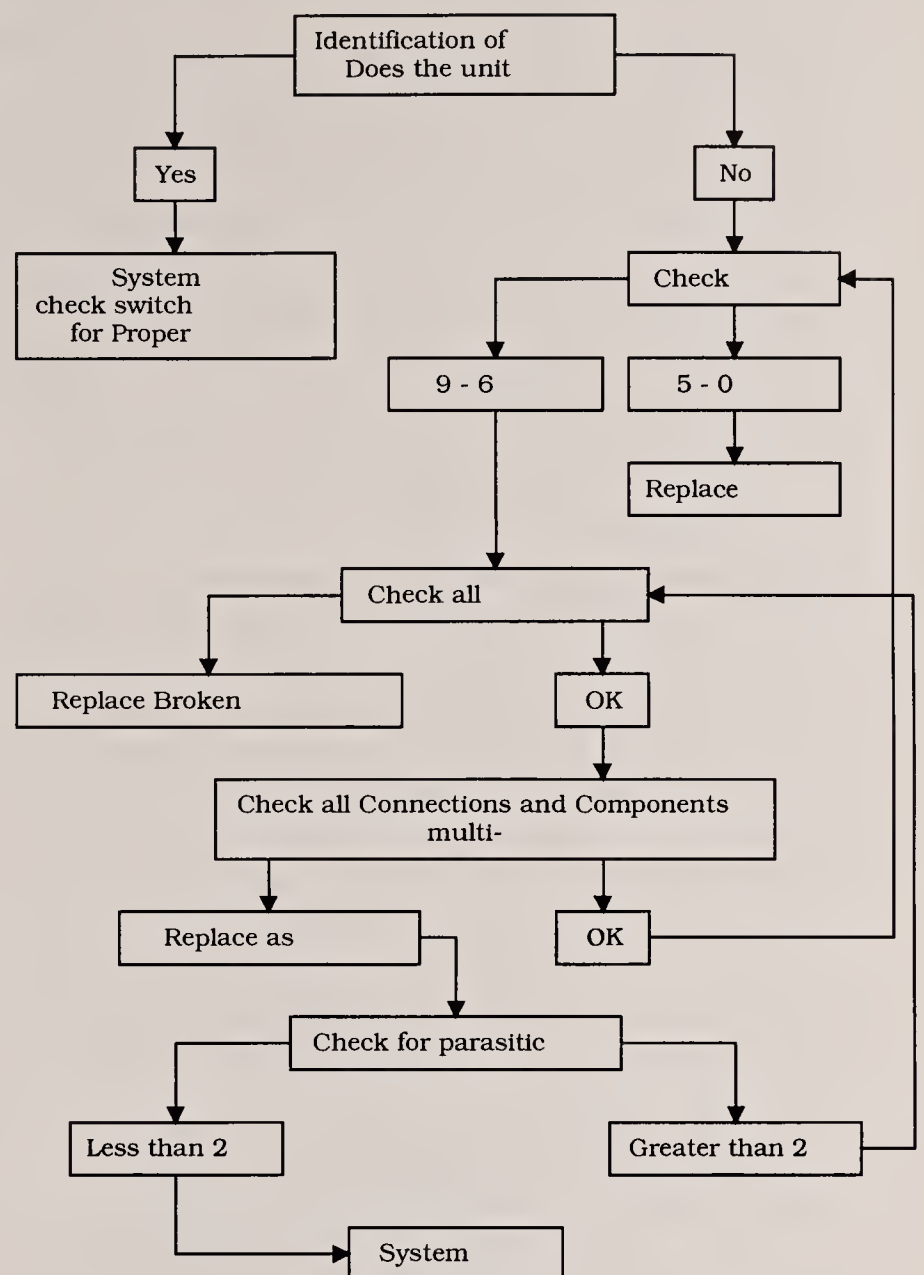


Figure 4.19. Flow Chart.

The total cost of the materials for the repairs and enhancements to Mr. Shifter and Waterworks III is less than \$100.

Kite and Blimp Flying Machine for a Person in a Wheelchair

Designers: Marc Mauro, Chris Shuler, Peter Slater

Client Coordinator: Dan Schipf

Brandywine Nursing Home, Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

Hobbies are crucial activities for people with disabilities. Before his diving accident, the client enjoyed flying kites. He expressed the desire to be able to do this activity again from his wheelchair. The designers drew on their knowledge of fishing equipment and planned to mount a downrigger to the wheelchair. Starting with this possibility, they dealt with the power and safety aspects, and decided on a battery operated system that did not depend on the power of the chair. In the course of development they introduced the concept of helium balloons both to launch the kite and to provide additional entertainment.

SUMMARY OF IMPACT

The specific requirements met are:

- The unit fits on the wheelchair securely; and
- Problems of liftoff and retrieval have been minimized.

The client spent several days with the designers, trying out several kites and balloons. He now has the system available to him.



Figure 4.20. Kite and Blimp Flying Machine for a Person in a Wheelchair.



Figure 4.21. Client with Pole Mounted on Chair.

TECHNICAL DESCRIPTION

Figure 4.20 shows the three designers with the essential components of the fishing equipment and kite used in the project. The kites and blimp are controlled by a fishing pole, six feet long, attached to the wheelchair and outfitted with an electric reel. Experiments

were conducted with state-of-the-art fishing equipment until an optimum combination was found. The resulting apparatus consisted of an aluminum holster to hold the base of the pole that fits neatly on the wheelchair. The holster had a swivel feature that is well suited for the client's needs. After experimentation, it was determined that he would require an extremely light kite. Four such light kites were purchased and were found useful. Also, the designers contributed the concept that the project should include objects lighter than air to provide amusement, i.e., mini-blimps. These were constructed and proved to be a welcome feature. Figure 4.21 shows the client with the pole mounted on his chair and one of the mini-blimps, the Star Trek Mylar balloon, hovering overhead.

Figure 4.22 depicts the assembly of components for the project, including the manner of attachment of the

fishing pole to the chair and the position of the battery.

Initially, the wheelchair battery was considered as the power source as it had been in earlier projects, e.g., *Batteries not Included* (1992). However, analysis proved that the kite flying machine would likely drain the battery quickly and that an independent power source was needed. This power source consists of a 12-volt rechargeable battery that is capable of providing continuous power for eight hours. The dimensions of this battery are 12 x 8 x 6 inches, very compact for mounting on the wheelchair. Figure 4.23 shows details of the battery placement.

The cost of the Kite and Blimp Flying Machine is \$863.

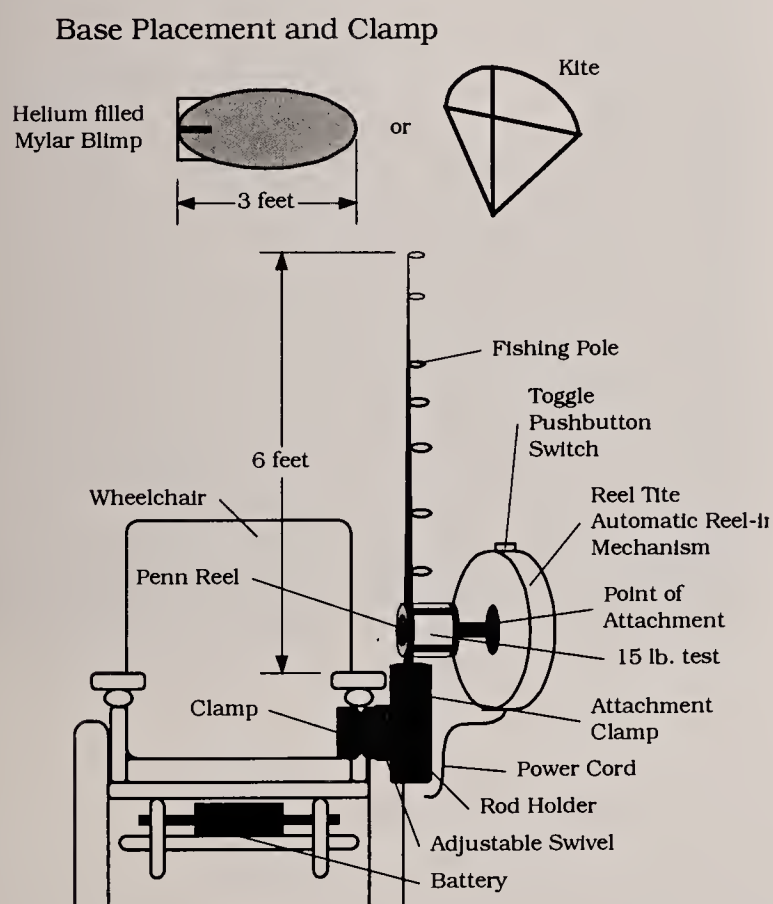


Figure 4.22. Assembly of Components.

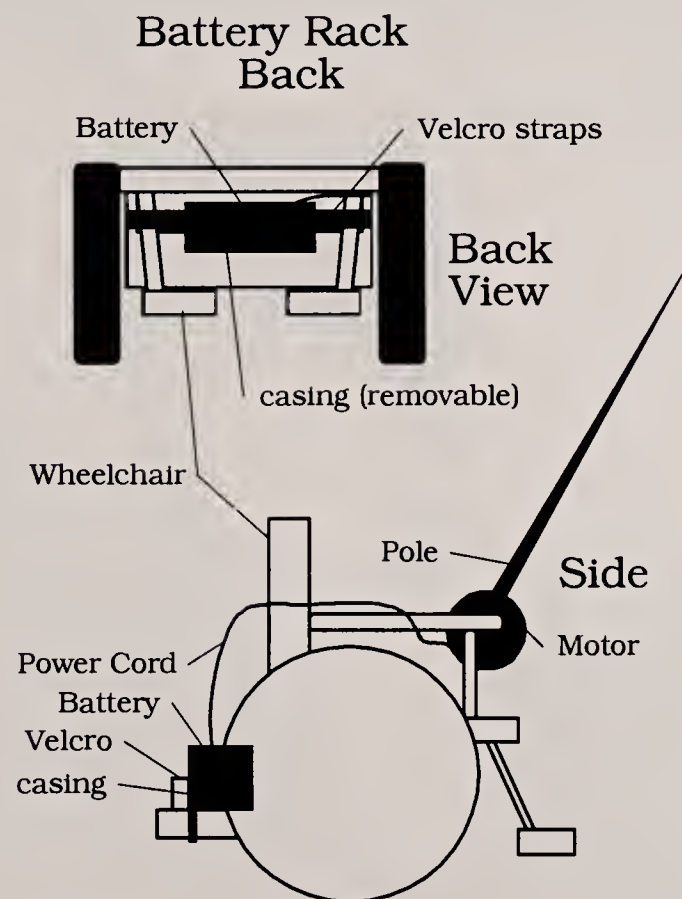


Figure 4.23. Detail of Battery Placement.

Pop-a-Wheelie Hair Washing Stand

Designers: Chris Cantelmi, Eugene Hundertmark, Peter Slater

Client Coordinator: Dan Schipf

Brandywine Nursing Home, Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

Residents of the Brandywine Nursing Home expressed the wish to have a means of washing their hair that more closely resembled normal conditions. The new design involved the ability tilt a person backward with the back of his or head over a basin. Most residents in wheelchairs are unable to be tilted in this way with conventional equipment. The solution was an L-shaped platform on which the wheelchair is mounted. The entire unit, wheelchair and platform are tilted back by means of a hinge and foot pump.



Figure 4.24. Pop-a-Wheelie Hair Washing Stand.



Figure 4.25. Pop-a-Wheelie Hair Washing Stand in Raised Position.

SUMMARY OF IMPACT

This project fell short of expectations because of a misunderstanding of specifications. The designers carried out the project with customary contact and review of progress with the customer. However, when the Pop-a-Wheelie was delivered to Brandywine, it was found to have a back rest that was too high for convenience in the hair salon. This outcome was dis-

appointing, but the opportunity to modify the device during the next year is anticipated.

TECHNICAL DESCRIPTION

After two major design revisions the final design was determined to consist of an L-shaped platform that rotates on a hinge mounted on a portable base. The frame is built of 1.5 inch welded steel tubing. Figure 4.24 shows the Pop-a-wheel Hair Washing Stand in the lowered position with the three designers.

The most important component of the device is the jack mechanism. A Dayton bottle jack was selected; however, it needed modification. A pin connection was needed at the base to allow the jack to rotate with the frame. This was accomplished with modified tubing components and a bolt. The jack originally was operated by hand pumping action. This action was altered with the addition of a foot pedal with a strap. Also a lever was added to the release valve switch to make it easily operated by foot. The travel of the lever was limited so that descent was at a slow,

comfortable rate. Figure 4.25 shows the Pop-a-Wheelie in the raised position.

Since the Pop-a-Wheelie had to be portable, wheels were needed. Any available set of wheels required far too much space beneath the platform; the wheelchair would be much too high. The solution was to mount the wheels outboard. This step required special mounts that were also fabricated from the square tubing stock. The front wheels are swivel castors, capable of 360-degree rotation. These castors had foot locks that can lock both the swivel and rotation. A side view of the device with parts labeled is shown in Figure 4.26.

Safety considerations were met by the creation of a railing around three sides with the steel tubing. Also, a safety strap is provided to hold down the front of the wheelchair when the platform is tipped during use.

The cost of the Pop-a-Wheelie is \$258.

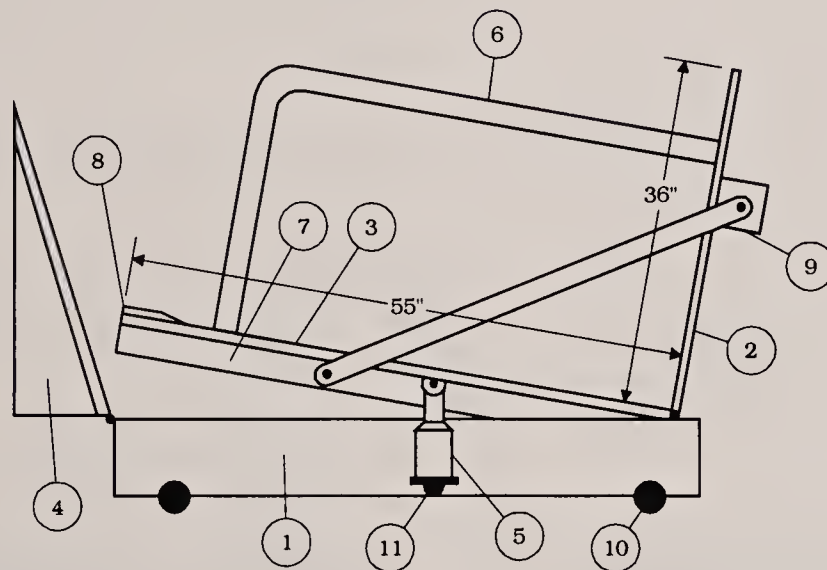


Figure 4.26. Diagram of Hair Washing Stand.

1. Wooden Frame: $\frac{3}{4}$ -inch particle board with 2x4 bracing
2. Platform Back: $\frac{3}{4}$ -inch particle board
3. Platform Base: $\frac{3}{4}$ -inch particle board
4. Hinged Ramp: $\frac{3}{4}$ -inch particle board with 1x1 bracing
5. Dayton Bottle Jack: 2 ton capacity, 6.5-inch vertical lift
6. Safety Bar: 1.24-inch diameter Steel tubing
7. Angle Iron Reinforcement: 1.5x1.5x0.125-inch steel
8. Safety Wheel Chock: angle cut wood stock
9. Angle Iron Mounting Bracket: 1.5x1.5x0.125-inch steel
10. Wheels: Self locking, industrial
11. Jack Mountain Bar: 1x0.125-inch steel tubing

Lazy Susan Plant Watering Device

Designers: Joseph DeNivo; Peter Murphy, Jennifer Nold

Client Coordinators: Susan Holmes, OT, Dan Schipf

Brandywine Nursing Home; Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

Susan Holmes, an occupational therapist, has found the Waterworks devices very helpful in her greenhouse projects. She suggested a new device to allow one resident to apply water to several plants without the need of assistance. The Lazy Susan is a compact device that allows at least four plants to be so treated. It is motorized and operated by the conventional assortment of switches developed for other projects. Technology developed from former Waterworks projects enabled the designers to build another Waterworks tank and pump assembly for use with this Lazy Susan.

SUMMARY OF IMPACT

The Lazy Susan provides the desired versatility to greenhouse activities. It fits, as required, in a 22-inch square area. To meet the request that as much of the device as possible be visible, much of the material is clear acrylic. Finally, as is customary with all greenhouse projects, it was required that the device not depend on line current. Therefore, DC power was provided. Final determination of its acceptability depends on the upcoming feedback from Susan Holmes and the residents.



Figure 4.27. Lazy Susan Plant Watering Device.

TECHNICAL DESCRIPTION

Figure 4.27 shows the three designers with the Lazy Susan and Waterworks unit.

The Lazy Susan consists of a 22-inch diameter circular platform that rotates and forms the surface on which the plants rest. This platform surface is made of clear acrylic and is mounted on a metal rotating base adapted from Lazy Susan cabinet shelving. After several stages in the design process, the drive train selected was a chain and sprocket. A sprocket is mounted on the shaft of a 12-volt DC motor. The second sprocket is mounted on the central axes of the platform. It rotates with the platform. Fig. 3.28 shows a close-up view of the Lazy Susan and companion Waterworks.

A side view of the Lazy Susan with labeled parts is shown in Figure 4.29.

The power supply is a 12-volt, seven-amp rechargeable battery. The high amperage is needed for the requirements of the DC motor.

Since Lazy Susan is to be used in conjunction with the plant watering tasks, the technology for the watering

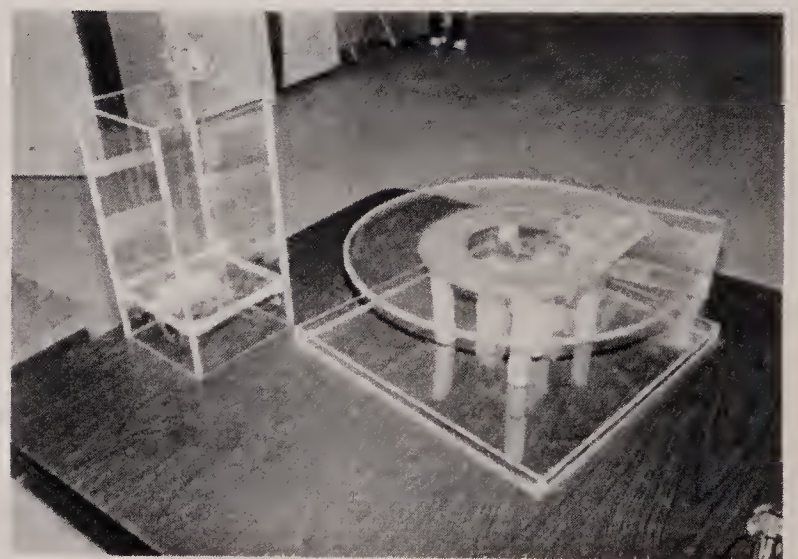


Figure 4.28. Close-up View of The Lazy Susan and Companion Waterworks.

operation was borrowed from the Waterworks II project of 1994. A separate Waterworks unit was built for Lazy Susan.

The Waterworks element is featured in Figure 4.30.

The cost of materials for the Lazy Susan is \$356.

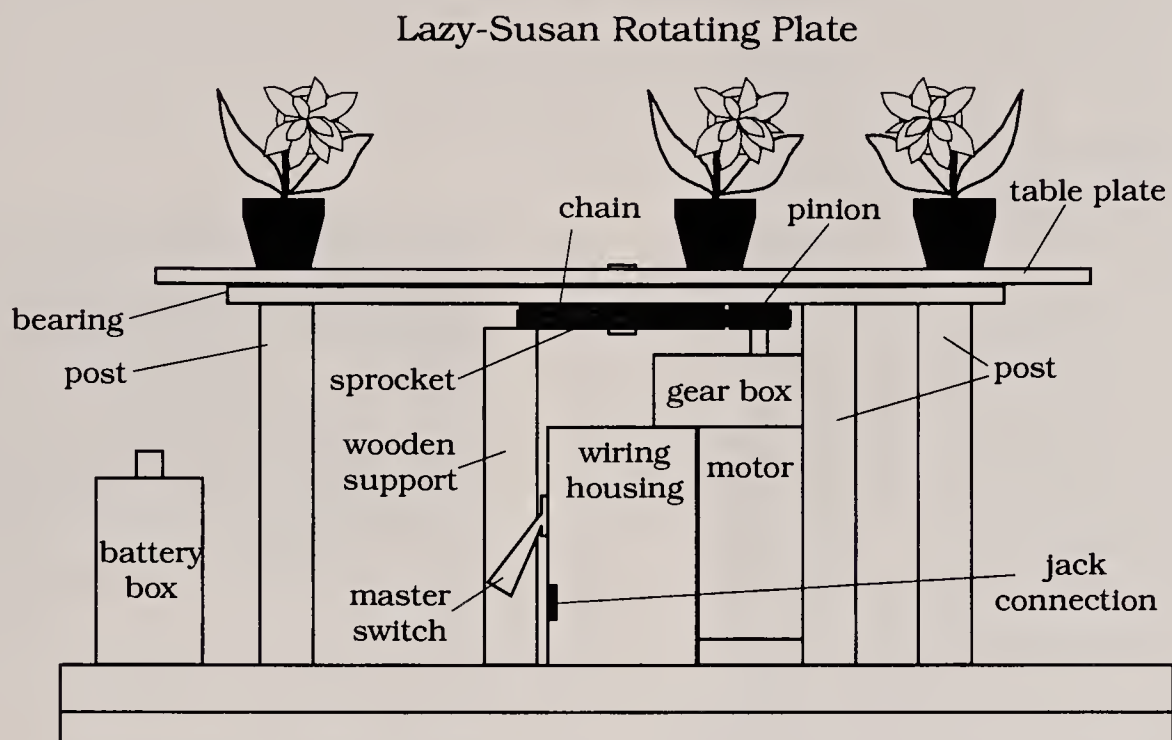


Figure 4.29. Side View of the Lazy Susan.

Waterworks (Shower Element)

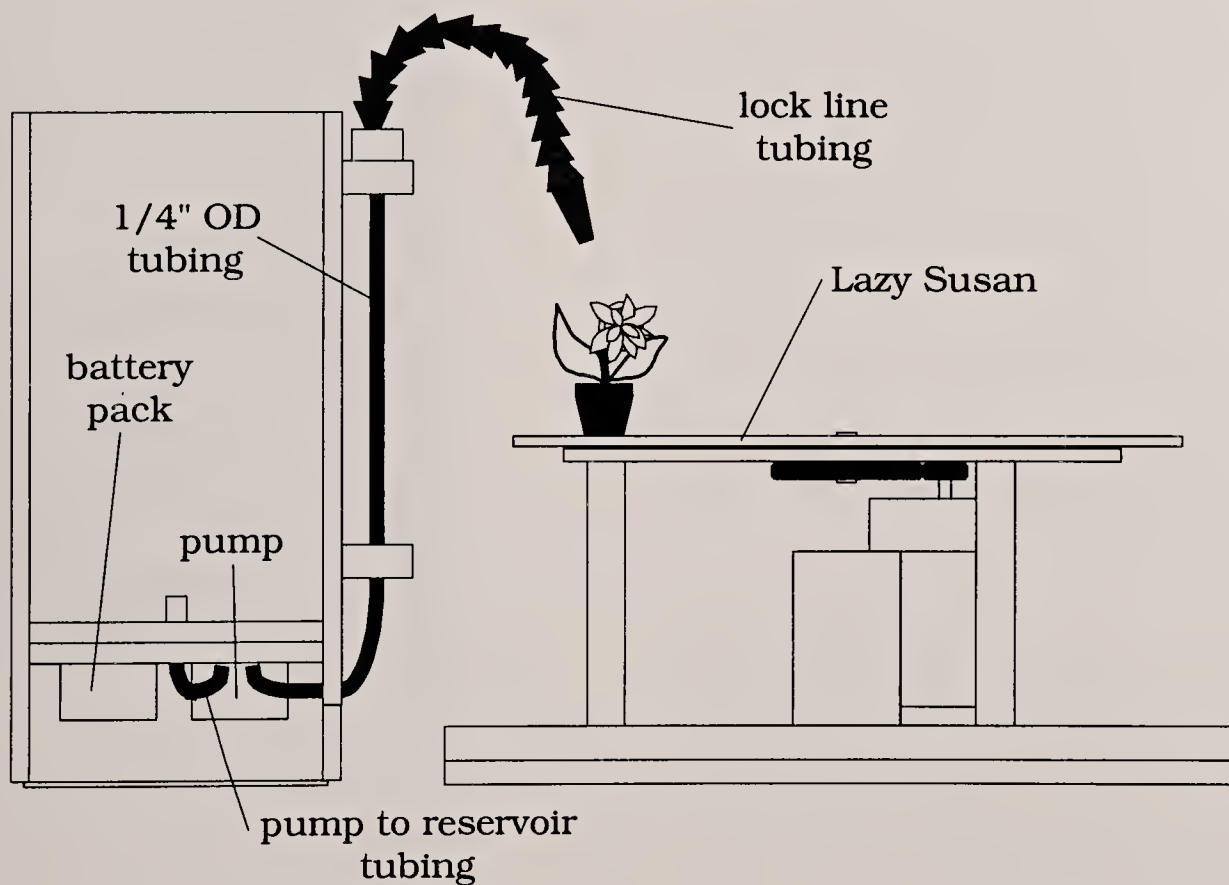


Figure 4.30. Waterworks Element.

Happy Motion Wheelchair

Designers: Christina Curry, Richard Eskew, Katherine Giles

Client Coordinators: Laura Meza; OT, Dan Schipf

Brandywine Nursing Home, Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

Some nursing home residents are unable to sit in an ordinary rocking chair but wish that they could. Some devices that allow wheelchair-bound patients to rock are commercially available, but expensive. Laura Meza, an occupational therapist, requested a rocking device on which a wheelchair could be easily mounted at reasonable cost.

SUMMARY OF IMPACT

Two custom-built Happy Motion rockers were provided, one for general purposes and another for a resident with special requirements.

TECHNICAL DESCRIPTION

After considering use of various materials, including aluminum, wood was selected as the primary material because of its suitability, low cost and ease of fabrication. Happy Motion is basically a platform with a curved base to permit the rocking motion. The wheelchair is mounted on the platform surface composed of $\frac{1}{4}$ -inch plywood, reinforced on the underside. The platform is set in two side rails with a curved base which are cut from two sections of 2 x 6 inch Douglas fir. The radius of curvature of the basic Happy Motion base is 60 inches, while that of the special Happy Motion is 90 inches. Straight slots, $\frac{1}{4}$ -inch wide, to accommodate the platform, were cut in these side rails. Figure 4.31 shows the two Happy Motion rockers side by side. Figure 4.32 shows the basic rocker in use by one of the Brandywine residents.

To assist in the use of Happy Motion, a small hinged ramp is provided at the rear. This ramp was requested in order to assure that only one attendant would be required to assist in the embarking and disembarking of the wheelchairs. However, it was found that highly functional residents and those in motorized wheelchairs could easily embark without any assistance at all.



Figure 4.31. Happy Motion Wheelchair.



Figure 4.32. Basic Rocker in Use.

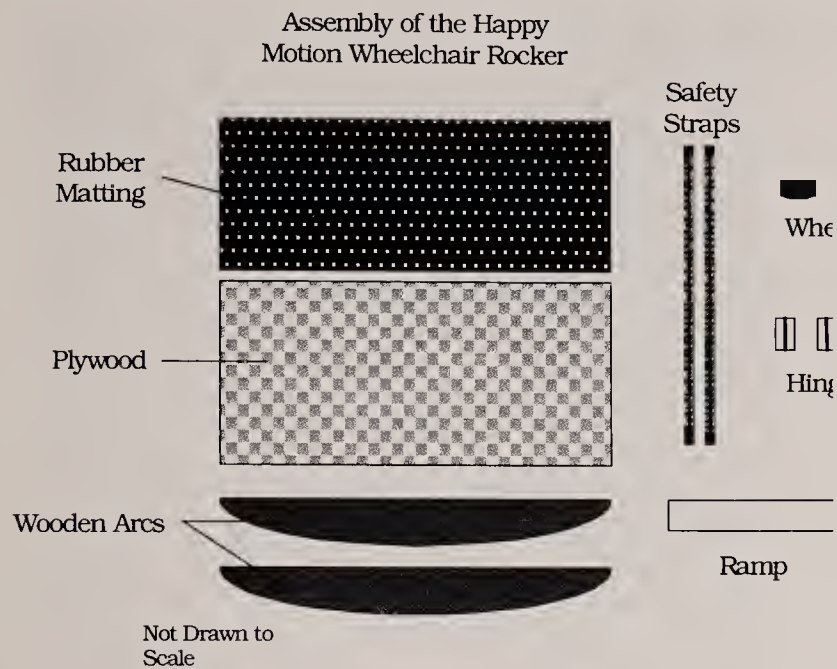


Figure 4.33. Assembly View of Happy Motion Rocker.

The flat surface proved to be slippery when testing began. The wheelchair wheels would skid on the surface. The designers added three safety features to address this problem. Rubber treads were added to the platform surface. An adjustable wooden bumper was added, and tie down straps were added to hold down the front of the chair while rocking. An assembly view of the Happy Motion rocker is shown in Figure 4.33.

Figure 4.34 shows the three designers with the smaller Happy Motion rocker.

The total cost of materials for the two Happy Motion rockers is \$194.



Figure 4.34. Designers with Happy Motion Rocker.

Lazy Walker

Designers: Juan Cazorla, Patrick Gordon, Alfred Nagib

Client Coordinators: Kathy Ruff; PT, Dan Schipf

Brandywine Nursing Home, Briarcliff Manor, NY

Supervising Professor: Dr. Daniel W. Haines

Mechanical Engineering Department

Manhattan College

Riverdale, NY 10471

INTRODUCTION

Kathy Ruff, an occupational therapist at the Brandywine Nursing Home, requested a walker that would allow the user to rest from time to time in a seated position without assistance. A walker was modified to include a seat that can be stored as the patient walks but easily installed by the user when needed.

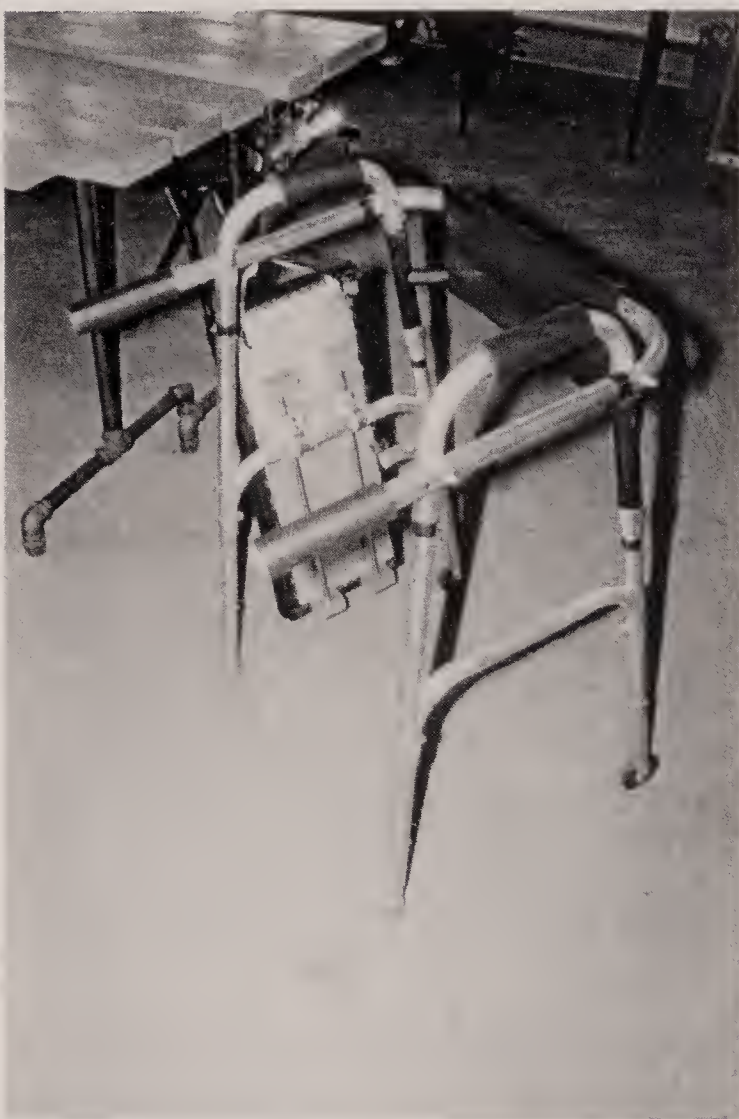


Figure 4.35. Lazy Walker.

SUMMARY OF IMPACT

The device was to include:

- A seat incorporated into the walker;
- Easy storage for the seat;
- A back rest for the seat; and
- Extension handrails to facilitate operation in the standing position

Additional design criteria were that:

- While using the seat mechanism, the walker remains stationary; and
- The walker must glide easily on smooth surfaces, even with the added weight of the seat

Due to an accident during the academic year, one of the designers, Juan Cazorla, was under the care of several physical therapists. He took this opportunity to have his therapists review the progress of the Lazy Walker. The client coordinators also reviewed the device. Several modifications were then made. When delivered to the clients, the additional improvements were appreciated. The clients are pleased with the product.

TECHNICAL DESCRIPTION

The basic challenge of this project was to add a seat to a standard walker. The walker had two wheels in front and two rubber stoppers on the rear legs. The side supports are horizontal and adjustable in height. This feature made it possible to accommodate the seat with minimal complication. The seat incorporated sandwich construction, a core of 3/8-inch plywood between two faces of 1/8-inch aluminum. This construction resulted in a seat with sufficient bending stiffness with minimal weight. Figure 4.35 shows the Lazy Walker with the seat retracted, ready for normal walking.



Figure 4.36. Lazy Walker with Seat in Place.

Figure 4.37 shows the three designers with their Lazy Walker.

The seat had to be capable of placement in a convenient location for seating, i.e., horizontal at the appropriate height between the side supports. It also had to



Figure 4.37. Designers with Lazy Walker.

be storable. It was installed at the side within one of the side supports such that it could be pivoted laterally for seating and then returned to storage position within the side support. Lateral motion for the seat is provided by two shafts mounted to the underside of the seat. The shafts slide through two linear motion pillow block bearings. Collars are mounted on the shafts to limit the amount of travel. Figure 4.38 shows the seat mechanism detail. To provide for the pivot action, the pillow block bearings are mounted on angular motion bearings that rotate on the horizontal side support bars. These bearings were adapted from vibration damping pipe supports. Figure 4.39 shows the movement of the seat. The total cost of materials for the Lazy Walker is \$140, not including the basic walker that was provided to the designers.

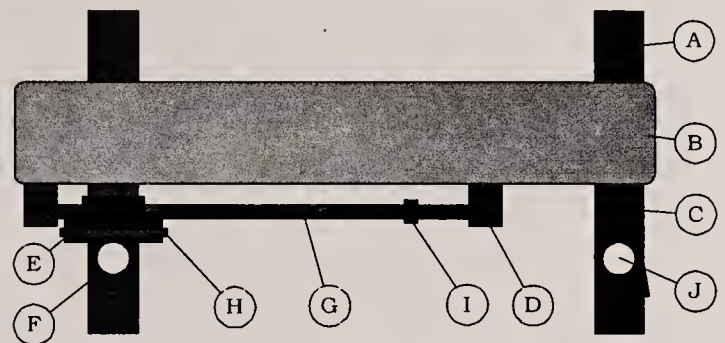


Figure 4.38. Seat Detail Mechanism.

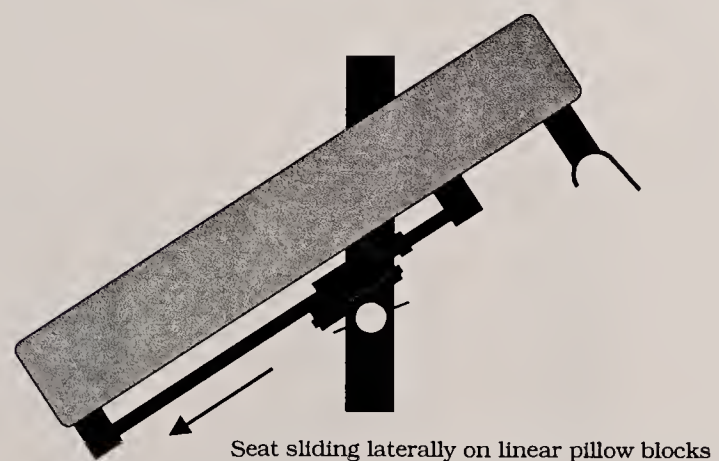
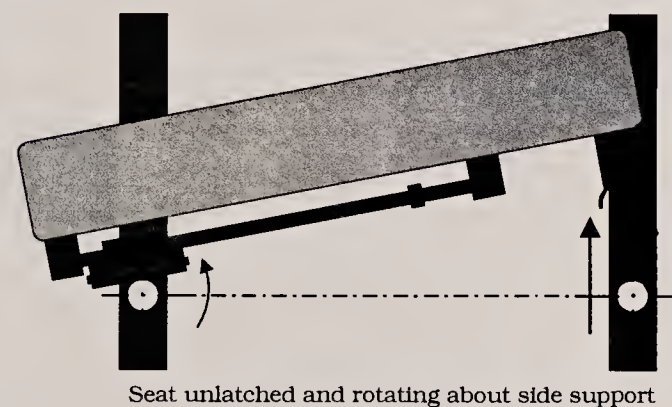


Figure 4.39. Movement of Seat Diagramed.



CHAPTER 5

MILWAUKEE SCHOOL OF ENGINEERING

**1025 NORTH BROADWAY
MILWAUKEE, WISCONSIN 53202-3109**

Principle Investigator:

*Thomas J. Swiontek, (414) 277-7344
swiontek@msoe.edu*

Linear Motion Deflasher: A Workstation for Handicapped Workers

Designers: Mike Alkire, Brian Peters, Mike Reilly, Lisa Slauson

Client Coordinator: Roger Van Ryzin

Portal Industries, Inc.

Supervising Professor: Dr. Daniel Brandt

Milwaukee School of Engineering

1025 N. Broadway

Milwaukee, WI 53202-3109

INTRODUCTION

The goal of this project was to design and construct a prototype of a machine to enable a handicapped person to perform a useful job function at Portal Industries, Inc. Workers had been filing by hand to finish molded plastic parts. This was a laborious and messy process. To improve the process, a workstation was designed to help remove most of the flashing from the plastic parts. The workstation can be operated by a person handicapped in hearing, speech or leg mobility. Good eye-hand coordination is required. The device is sized and positioned so that the work can be done from a sitting position. It can be used by a person

in a wheelchair.

SUMMARY OF IMPACT

It takes approximately 15 to 20 minutes to remove the flashing from the plastic molded part by hand. The process is also messy due to the amount of flashing that is being removed and the means by which it is being done. This job is considered undesirable by some workers due to the amount of dust created in the process. The workstation removes the majority of the plastic flashing in about five minutes. Some hand filing is needed after the workstation finishes the part, but this takes less than five minutes. The time per part is reduced to 10 minutes or less. The majority of

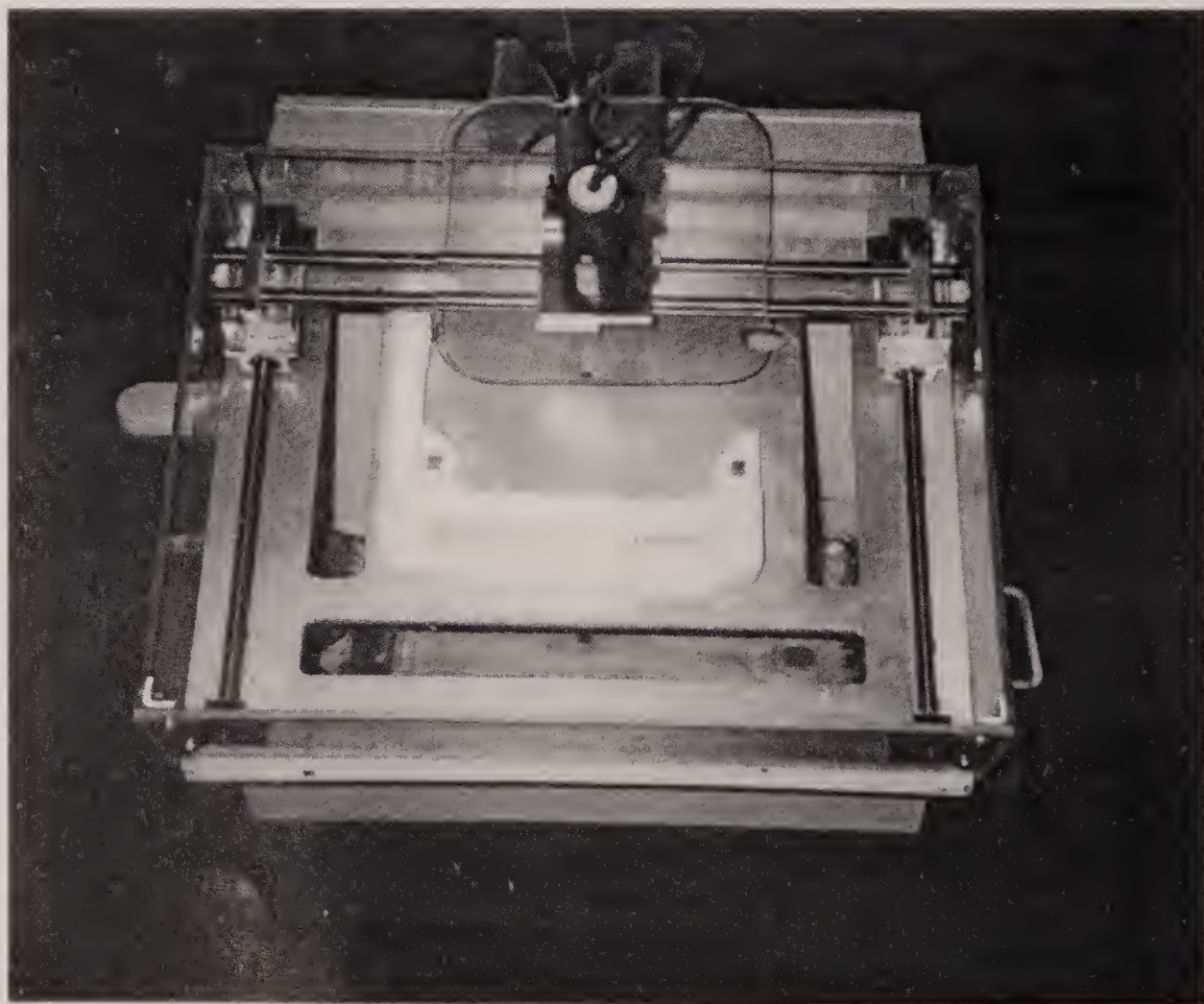


Figure 5.1. Top View of the Linear Motion Deflasher.

the flashing is removed in the workstation, and thus most of the debris goes into the dust collector drawer.

TECHNICAL DESCRIPTION

A basic layout of the design is shown in Figures 5.1 and 5.2. The workstation has a platform that sits at a 20-degree angle from horizontal so the worker can view the whole part at one time. The angle was also chosen so the debris would fall into the collection drawer. The platform is a 3/8-inch aluminum plate measuring 21 x 16 inches. The workstation has overall dimensions of approximately 18 inches tall, 24 inches deep, by 21 1/2 inches wide. The grinding mechanism is a rotary file driven by a variable speed motor (Fig. 5.2.). The rotary file is connected to the motor by means of a three-foot flexible shaft. The bit assembly moves with the aid of Thompson linear bearings on steel hardened 1/2-inch shafts that allow motion in a single plane.

To make room for inserting the part, the bit assembly is moved to the top of the workstation and held securely with a fixture. The worker then puts the part into the workstation from the top. The part is guided into place and held stationary by two locator pins. The worker detaches the bit assembly, depresses both triggers, and then grinds off the flashing. The flashing from the plastic part is removed by simply tracing the outline of the part.

There are many safety features built into the workstation. The first is the dual trigger design. One trigger is on the grip of the bit assembly and the other is on the grip mounted on the side of the workstation. Because workers must use both hands to activate the two triggers, they are not able to reach inside the workstation and have their hands come into contact with the rotating bit. There is also a Plexiglas guard on the top of the bit assembly to prevent any sleeves or hair from getting caught in the rotating bit. The workstation has Plexiglas side walls to contain the debris from the grinding and to prevent the worker from reaching in from the sides. There is a safety switch on the rear access panel of the workstation. This panel allows access to the electronics of the station, including the speed control and motor. The safety switch will open the circuit to prevent the risk of electric shock or the mechanism being turned on when the panel is opened. Finally, there is a fuse in the circuit that will prevent the motor from drawing too much current.

The final cost of the Linear Motion Deflasher was \$736. The majority of this cost was for the linear bearings and the hardened steel shafts, which totaled \$509. The machining of the aluminum plate and the bit assembly were done in the machine shop of the Milwaukee School of Engineering, thus reducing the construction cost.

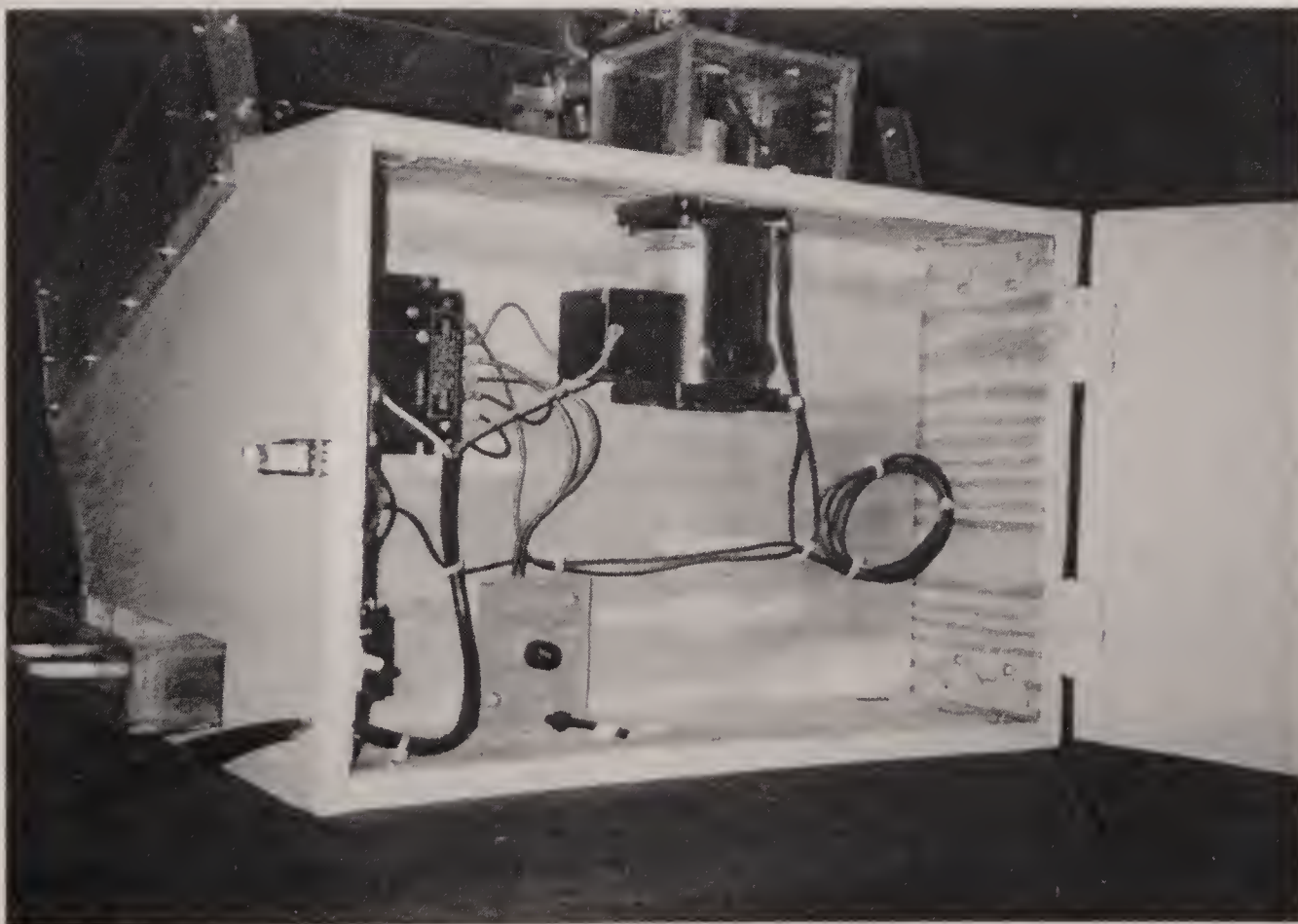


Figure 5.2. Back and Inside View of Linear Motion Deflasher.



CHAPTER 6

MISSISSIPPI STATE UNIVERSITY

College of Engineering
Department of Agricultural and Biological Engineering
Box 9632
Mississippi State, Mississippi 39762-9632

Principal Investigators:

Jerome A. Gilbert (601) 325-3280
Jonathan W. Pote (601) 325-3282

An Ultrasonic Ranging System for the Blind

Designer: David T. Batarseh

Client Coordinator: Ms. Debbie Baker-Upton, MSU Student Support Services

Supervising Professors: Drs. Timothy N. Burcham, Filip S. To, Gary M. McFadyen, Jerome A. Gilbert

Department of Agricultural and Biological Engineering

Mississippi State University

Mississippi State, MS 39762

INTRODUCTION

The purpose of this senior design project is to develop a mobile ultrasonic ranging system for the blind. Currently, the most common method of range detecting used by blind people is the walking stick. The walking stick is economical, durable, and serves its limited purpose well. The limitation of the walking stick is that a blind person must come into close proximity with their surroundings to determine where an obstacle may be (i.e., bumping into walls and trees). This project uses the Sona Switch™ 1700 ultrasonic sensor to solve this problem. This sensor has 1) a DC voltage output that is a linear analog of the distance measured and 2) an internal solid state switch. Properly designed circuitry converts the DC voltage from the Sona Switch into an AC frequency that drives (oscillates) two small headphone speakers. The result is a system that produces a varying frequency of chirps that is a linear analog of the distance measured. By becoming acquainted with the different frequency of chirps emitted by the speakers, the user can estimate the proximity of an object. The user can also use the Sona Switch's internal switch mechanism. As described more thoroughly later, this mechanism allows for the production of a constant frequency of chirps on objects detected within a certain range. The sensor is mounted on a helmet allowing for mobility and control.

SUMMARY OF IMPACT

The ultrasonic ranging system developed allows a blind individual to "see" pathway obstacles that are outside the walking stick range and determine the distance to the obstacles. The device works in both outdoor and indoor conditions. For example, a blind individual can walk within a parking lot and determine the relative distances to the parked cars. The individual can use the apparatus inside a building to determine if he or she is in a hallway, where the doorway is to a room, and to estimate the perimeter of the room. However, this system requires practice in order to be useful. For example, when a blind indi-

vidual is walking down a hall, he or she will hear a frequency of chirps while glancing left or right. While looking forward, the user hears nothing until the end of the hallway is reached (a wall). Over time, the user will recognize this pattern of chirps and correlate them with a hallway environment. With further practice, the user can form a mental picture of the environment based on the different patterns and frequency of chirps elicited. The user easily hears the frequency of chirps and can adjust the volume for different noise level environments.

TECHNICAL DESCRIPTION

The Sona Switch™ 1700 ultrasonic sensor is the main component of the ultrasonic ranging system. This sensor uses a pulse of ultrasonic waves to determine the distance to oncoming obstacles. The Sona Switch™ 1700 sensor has two essential features: 1) a DC voltage output that is a linear analog of the distance measured and 2) an internal solid state switch. These two features are used to produce a system that functions in an analog or digital mode of detection.

The analog mode of detection is accomplished by using the DC voltage output of the Sona Switch. Using computer calibration software, the Sona Switch is calibrated via an RS-232 serial port to produce a DC voltage output ranging linearly from five Volts on objects detected at 1.5 feet or less to zero Volts on objects detected at twelve feet or more. The analog voltage produced by the Sona Switch feeds into the AD654 monolithic voltage-to-frequency (V/F) converter. The AD654 converts the DC voltage from the Sona Switch into an AC square wave frequency that oscillates two small headphone speakers.

The frequency output of the AD654 varies proportionally to the output voltage from the Sona Switch according to the following equation:

$$Frequency_{out(AD654)} = \frac{4 \times V_{out}}{\Omega F}$$

Therefore, the frequency of chirps emitted by the speakers ranges linearly from zero Hz at distances greater than or equal to twelve feet ($0 V_{out}$) to 20 Hz at distances less than or equal to 1.5 feet ($5 V_{out}$). By becoming familiar with the different frequency of chirps emitted, the user can determine the proximity of an object

The digital mode of detection is accomplished by using the internal solid state switch of the Sona Switch and an installed external circuitry switch. The external switch disconnects the analog DC voltage output line leading from the Sona Switch into the AD654 and reconnects the AD654 voltage input to a five-Volt source. This source is a Radio Shack model 7805 five-Volt regulator. The internal switch of the Sona Switch relays the AD654 to ground. Upon object detection, the internal switch closes allowing current to drain from the five-Volt regulator through the AD 654 and into ground. The AD 654 then produces the corresponding frequency output of 20 Hz. The internal switch is computer calibrated to close at object detection depths less than or equal to five feet. This gives the user an "alarm" when they are within five feet of an oncoming obstacle.

The Sona Switch™ 1700 is mounted on a lightweight biker's helmet with the sensor face lying horizontally (See Figure 6.1). Mounting the sensor on the user's head allows for accurate depth perception in whichever direction the user may be facing. It also allows for excellent echo pulse response and less wave disturbance due to the conical wave output angle of the sensor. The speakers are the stereo "walkman" type without a headband. Power is supplied to the Sona Switch™ 1700, AD654, and speakers by a 15-volt 650 mAmp-hr. power source. The AD654, power source, and other circuitry components are soldered to a breadboard. The breadboard is encased in a plastic experimenter box, and attached to the user's belt. The power source which is constructed of twelve 1.25 V batteries is also enclosed in a separate experimenter

box and attached to the user's belt. Volume control, headphone and power jacks, and the input interface jack of the Sona Switch are also incorporated into the circuitry and experimenter boxes.

The final cost of the ultrasonic ranging system was approximately \$510. Further details may be obtained from the designer.



Figure 6.1 Ultrasonic Ranging Device.

Backpack Transfer Device

Designers: Thomas Cabell, Brian Deuter

Client Coordinator: Ms. Debbie Baker-Upton, MSU Student Support Services

Supervising Professors: Drs. G.M. McFadyen, J. Bumgardner

Department of Agricultural and Biological Engineering

Mississippi State University

Mississippi State, Mississippi 39762

INTRODUCTION

A backpack support, storage and transfer device has been designed to facilitate independence for a student with cerebral palsy. The device (Figure 6.2) consists of three components: the track, the carriage and the mounts. The track is aluminum and has a 90° curve in the middle of it. The carriage consists of six ball bearings and a rectangular piece of aluminum. One bearing supports the load while four others keep the rectangle tangent to the track. The mounts are also made of aluminum. The front mount clamps to one of the two main frame supports of the chair. The two rear mounts clamp to a bar that is mounted behind the seat of the chair. At present, many students in wheelchairs carry their books and belongings by wrapping the straps of their backpack around the two handles on their wheelchair. This is the best place for the books because it is out of the students' way and it does not interfere with the mobility and clearance of the chair. This results in a dependence on others for books and supplies in and out of class. The approach taken was to devise a system that would store the books behind the chair thereby maintaining the chair's profile and clearance while allowing the books to be moved to the side of the chair when needed.

SUMMARY OF IMPACT

This device was designed for a particular client but could be adapted to fit many styles of wheelchairs. Several of the client's friends in wheelchairs have expressed a great interest in the device as well. The client could not be more pleased. She is now able to retrieve her books and supplies whenever she wants and no longer has to rely on someone else for her books. This has increased her level of independence and freedom dramatically.

TECHNICAL DESCRIPTION

This device was designed for a particular client but could be adapted to fit many styles of wheelchairs. The main design requirements of the device were: 1)



Figure 6.2. Device Mounted on a Motorized Wheelchair.

the device, when not being used, had to be within the plane of the chair, i.e., no part of the device could extend past the rear wheels; 2) it had to be easily removed and remounted in case of emergency, or when the wheelchair was being transported by vehicle; 3) it had to be as light as possible so as not to affect the handling of the chair or to excessively drain the battery due to the increased weight; 4) it had to be motorized due to the limited strength and mobility of the client; 5) it had to guide the backpack far enough around to the side and at an accessible height to allow access by our client; 6) the device had to be mounted so that in no way does it damage or cause a permanent alteration to the chair.

The device consists of three main components: the track, the carriage and the mounts. The track is a 40 by 4 by ¼-inch rectangle of T6-6061 aluminum. It is curved 90 degrees roughly in the middle with the 4-inch-wide face mounted flush to the side of the wheelchair. At the front of the curved track is a piece

of aluminum box tubing, 1 by 1 by 18 inches. The tubing is mounted to the track with two 5/16 by 2-inch steel screws that insert into the front mount, which is clamped to the wheelchair frame under the left side of the chair. The track is supported in the rear by two rectangular shaped mounts, 2¼ by 2½ by 3 inches, which clamp around a bar mounted to the seat posts of the chair. These rear mounts are each secured by four ¼-inch allen bolts. The rear mounts are mounted four inches apart. The track is attached to these mounts by way of a block-in-channel mechanism. At the top of each rear mount is a smaller rectangle with a ¼-inch hole in it. Mounted to the track are two channels with each channel matching the length, width, and depth of the rectangle on the mounts clamped to the chair. The channels on the track slide down over these rectangles and a bolt is placed through the channel and the rectangle securing both together. The channels are attached to the track by aluminum spacers, 1 by 1½ by 2½ inches. These spacers are then attached to aluminum plates, 2 ½ by 3 ½ by ¼ inches, which are mounted to the track via four ¼-inch countersunk allen bolts.

The carriage uses six 7/8 by ¼-inch ball bearings to support and guide the weight of the books. One bearing is located at the top of the carriage and supports the load. It runs along the ¼-inch-wide top of the aluminum track. The bearing is attached to carriage by a 5/16-inch steel bolt. The backbone of the carriage is a rectangular piece of aluminum, 1 by 3/8 by 6 inches. Mounted to the other side of the top bearing is a rectangular piece of aluminum, ½ by 2 by ¾ inches, in which is mounted two more bearings that are mounted horizontal and tangent to the inside of the track. These bearings react against the weight of the books to pull the top bearing off the track. On the other side of the track in between the carriage backbone and the track is another set of bearings mounted 1½ inches from the bottom of the track. These bearings are mounted horizontally, i.e., perpendicular to the track, and also react against the weight of the books pushing the carriage into the track. These bearings also keep the carriage tangent to the plane of the track as it moves around the curve. A sixth bearing is mounted underneath the track to promote rotational stability and to stabilize the carriage when encountering bumps and other jars. Attached to the backbone of the carriage is an L-shaped piece of aluminum made of two pieces welded together. The

vertical piece is 10 by 5 by ¼ inches. The horizontal piece is 9 by 6 by ¼ inches. This L-shaped has 5 5/16-inch holes in it through which the backpack is attached via grommets inserted in the backpack in the corresponding areas.

Backpack transportation is provided by a 24V DC reversible gear motor attached directly to the rear of the track. This motor is powered by the 24V system of the wheelchair and is powered by plugging an ASM three-prong plug into the recharge jack. The backpack is then moved by a cable that is wrapped in opposite directions on a partitioned drum that is mounted to the shaft of the motor. The cable is wrapped around a nylon bushing that is located on the front of the track. The carriage is attached to the cable by a screw and washer that is tightened down over the cable. The cable runs between the track and carriage.

Two lever-type limit switches are mounted to the track to prevent motor overload and burnout. Both switches are wired in the normally closed position. One switch is mounted at the front of the track just before the aluminum box track support. This switch is wired to cut the power in one direction only so that contacting the switch opens the circuit that moves the pack forward but the backwards circuit is still closed. The second limit switch is mounted to the rear of the track and prevents the backpack from running into the motor in the same manor as the first switch. The system is controlled by a DPDT on-off-on switch mounted to the front of the track.

The device was mounted and tested on our client's chair for one week. The device performed well under normal, everyday classroom situations and in travel across campus. The device moved the books from the rear of the chair to the side without problems and our client was able to have access to her books whenever she wanted. The device is easily removable with only the mounts remaining permanently on the chair. These can also be removed with no damage to the chair.

Final cost of the backpack transfer system is approximately \$1,300 including parts and labor.

Motorized Wheelchair Table

Designers: Jason Keeley & Michael Roach

Client Coordinator: Ms. Debbie Baker-Upton, MSU Student Support Services

Supervising Professor: Drs. G. McFadyen, S. D. To, J. Gilbert and Ms. Kim Reed

Agricultural and Biological Engineering

Mississippi State, MS 39762-5465

INTRODUCTION

In many of the classrooms on campus at our university, tables are not readily available to students with disabilities for taking notes or doing class work.

These students have tried wheelchair tables in the past and have not been pleased with the disadvantages of such devices. There were a number of factors to consider in designing such a device for them. Some of the disabled students had an arm reach basically limited to the armrest of their wheelchair. This made it difficult to move tables that required reaching outside the armrest. Strength is also a limiting factor; some of the students can only lift relatively small weights, less than five pounds, repeatedly. In the past, because of these limiting factors, assistance was needed for these students to be able to move a wheelchair table in and out of position.

The purpose of this project was to deal with these limitations by designing a motorized wheelchair table that could be operated repeatedly and independently. The design mounts the device on the side of the wheelchair, with a switch in an easily accessible position for the student. The motor will rotate the table from the in use to the stored position shown in Figures 6.3 and 6.4.

SUMMARY OF IMPACT

Disabled students are sometimes reluctant to use facilities that do not accommodate them properly. This device will allow these students to enjoy the use of a table for doing in-class work, as well as work outside of the classroom. The device is controlled via a switch mounted in a convenient position on the wheelchair, and therefore will not require the assistance of others. Devices such as this one give such students more independence in their daily lives.



Figure 6.3. Table In Use Position.

TECHNICAL DESCRIPTION

The table is rotated in and out of position by a 12-VDC geared motor. The motor provides 43 in-lb of torque at 4.5 RPM. A circuit was constructed to control the device. It contains a double-pole double-throw momentary ON-OFF-ON switch that allows the motor to move the table between positions. When the switch is pressed in the forward direction, an electrical path is established between the battery and relay-2 as shown. This allows the motor to rotate the table until it makes contact with limit-2, which energizes relay-2 and establishes an alternate path to reverse the process when the switch is thrown in the reverse direction.

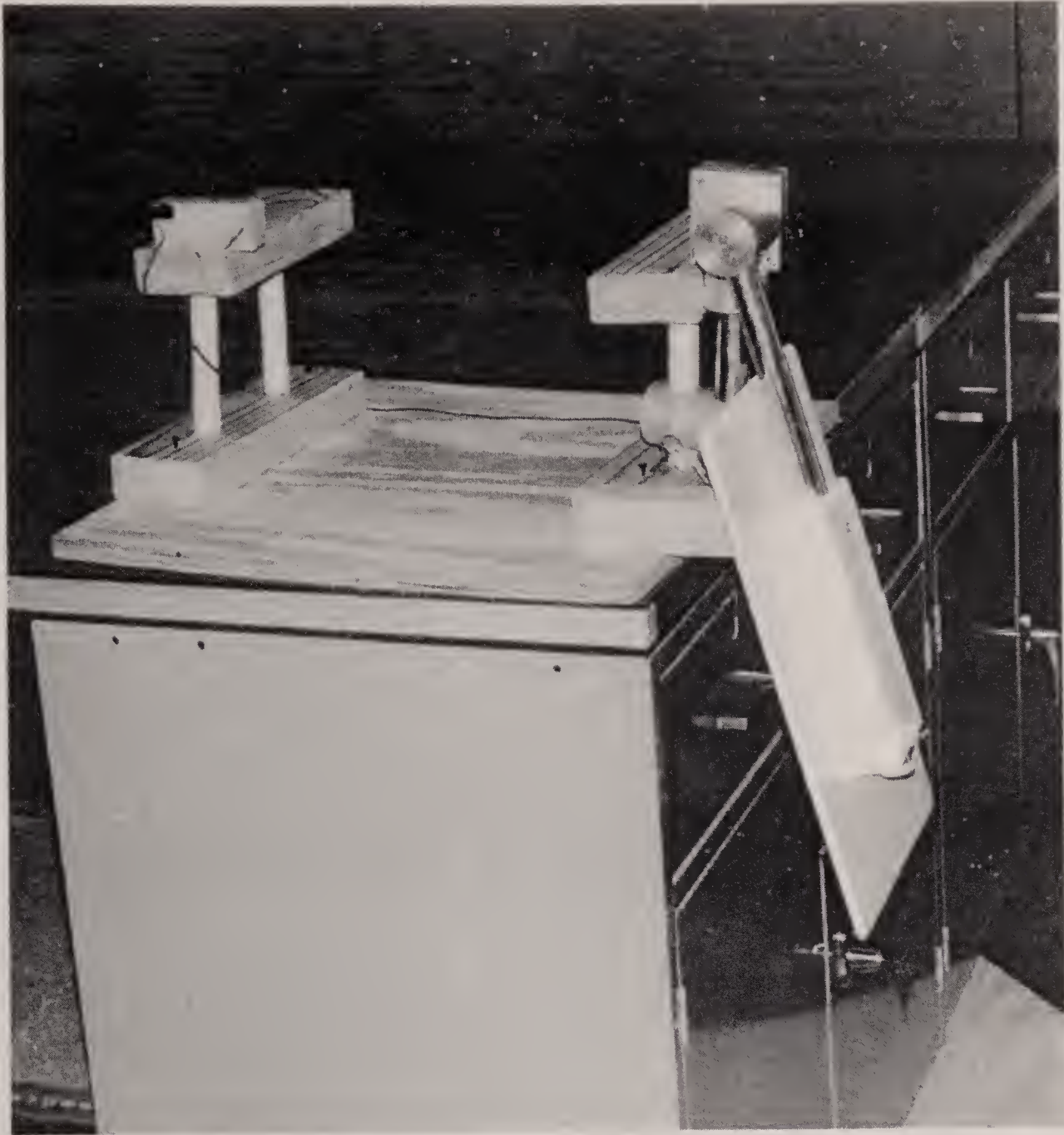


Figure 6.4. Table in Stored Position.

The Dog Walker

Designer: Kendra Ferrell

Client Coordinators: Mr. Mike White, Ms. Debbie Baker-Upton, MSU Student Support Services

Supervising Professors: Ms. Kim Read, Dr. G. McFadyen

Department of Biological Engineering

Mississippi State University

Mississippi State, MS 39762

INTRODUCTION

A device has been designed to aid a disabled client in walking his dog. The design consists of two components, a connector piece and a latching spring. The connector piece is a "u" shaped piece that fits snugly on the client's wheelchair. While not in use, the piece remains on the chair and can be disassembled if needed. The latching spring can be connected on two sides, one side to the dog's leash and one side to the connector piece on the chair. The latching spring can be removed along with the leash when not in use.

SUMMARY OF IMPACT

A paraplegic needs the use of his hands to control his movement in a wheelchair. If he wishes to walk his dog, he must hold the leash of the dog as well as propel himself along. This could cause injury if the dog lunges out of control or if the leash tangles in the wheel of the chair. It is important that the client has full control of the wheelchair in the event of such cases. The dog walker meets these needs of the client.

TECHNICAL DESCRIPTION

The dog walker was designed with a particular student-client in mind, but could be both beneficial and recreational to many student-clients. The main design requirements of the swing were: 1) it had to control the dog's lunges so as not to pull the client over; 2) it could not void the warranty the wheelchair; 3) it would be lightweight; 4) it would be easy to remove if the need arose; 5) it would not be in the way while in use; and 6) it would allow the client to propel himself along without the hassle of holding the dog's leash. Finally, it had to be safe to use.

The dog walker has two main components, the connector piece and the latching spring. The connector piece is an aluminum piece that was bent to fit a 1-inch diameter bar on the client's chair. Two ¼-inch holes were drilled in the connector piece, one being flush with the wheelchair bar and the other being an inch above to allow for connection of the latching spring.

The latching spring consisted simply of a spring with two clasps placed on either side, one to attach to the connector piece and one to attach to the leash of the dog.

In order to find the proper spring for the device, the force that the dog pulled was measured with the use of a scale similar to a fish scale. From this, a factor of safety of 2 was calculated and the proper spring was chosen. The proper bolts were found by calculating the shear force of the bolts on the device.

In order to find the proper placement of the device, testing of the device was conducted by having the client place the device on his chair in two different locations, the front and the back. The proper placement of the device was found to be on the back of the client's wheelchair where it would be easily accessed, would control the dog's lunges, and would be out of the way when not in use. One modification that came out of this test was the use of shorter leashes.

The final cost of the wheelchair spring was approximately \$40.



Figure 6.5. The Attachment of the Connector and Latching Spring to the Wheel-chair.

Wax Dispenser

Designer: Theresa Polk

Client Coordinators: Mr. Mike White, Ms. Debbie Baker-Upton, MSU Student Support Services

Advising Professors: Drs. G. M. McFadyen and S. D. To

Agricultural and Biological Engineering

Mississippi State University

Mississippi State, MS 39762

INTRODUCTION

Allied Enterprises is a company that evaluates and trains individuals with disabilities in a real-life-manufacturing environment. One of their training facilities produces candles. Currently, the employees use metal pitchers to fill the candle containers with wax. This method has proven difficult for the employees to master and creates too much variation in the amount of wax poured into each jar.

The approach taken to solve this problem was to automate the candle pouring process. Several requirements had to be considered in the design. The first was that it had to be simple to use. This is because the device will be used by employees with cognitive impairments. The second requirement was that the volume of wax dispensed had to be adjustable to account for the various sizes of candles poured. Other requirements were that it had to be easy to clean and have a capacity of at least two quarts to prevent frequent filling.

The selected design has a battery operated time delay relay and solenoids (Fig. 6.6). The solenoids are attached to a plug in a funnel. The relay is set to operate the solenoids that control the volume of wax dispensed from the funnel. The employees are required to fill the funnel with wax, set the relay for the size of the candle to be poured, roll the device over the jar and push the button. This is simple enough for them to use. The one and one quarter gallon funnel can be unscrewed from the container to be cleaned.

SUMMARY OF IMPACT

The recipients of the device can now work more efficiently. They operate the device by rolling it over the empty candle containers and pressing a switch. The device automatically fills the candle jars. There are fewer errors so employees spend less time re-pouring unacceptable candles.



Figure 6.6. Outside View of Candle Wax Dispenser.

DESIGN ALTERNATIVES

The original design was for a valve in the spout of the funnel that would control the out flow of wax. This design was not implemented because of the cost of the necessary valve. The use of the solenoids and the other necessary changes were much more cost effective.

TECHNICAL DESCRIPTION

The funnel acts as a holding tank for the hot wax. The employees adjust the time delay relay for the size of the candle being poured. Then they push the switch. The solenoids pull on the lever that pulls the plug in the bottom of the funnel. The relay keeps the solenoids on for the allotted time and then releases, plugging the funnel. The employees then roll to the next

candle and repeat the process. The total cost of the project was \$250.

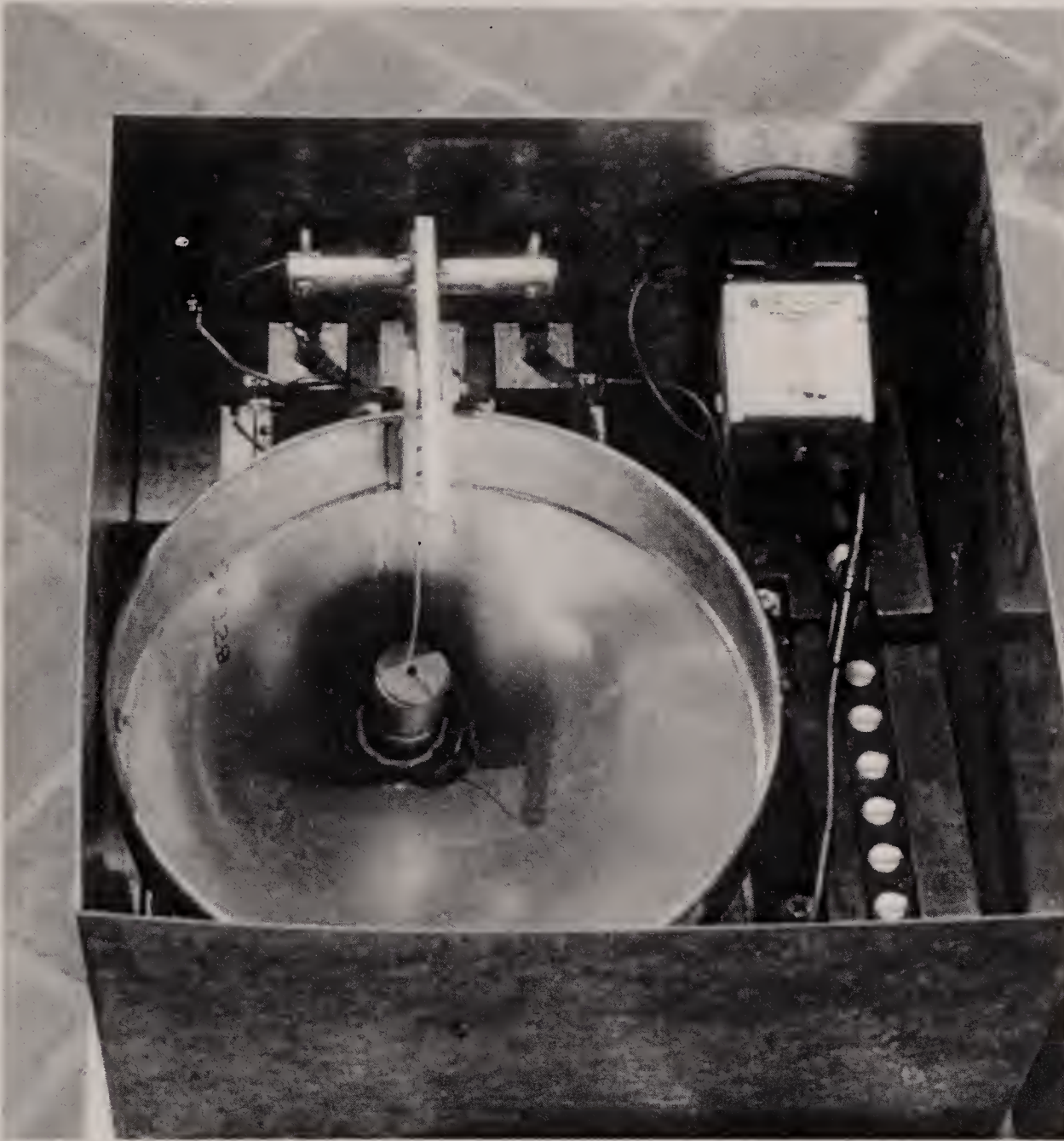


Figure 6.7. Inside view of Candle Wax Dispenser

Quad-Friendly Lap Table

Designer: Kris Geroux

Client Coordinators: Mr. Mike White, Ms. Debbie Baker-Upton, MSU Student Support Services

Supervising Professors: Dr. Gary McFadyen, Ms. Kim Reed, and Dr. Jerome Gilbert

Department of Agricultural and Biological Engineering

Mississippi State University

Mississippi State, MS 39762

INTRODUCTION

A wheelchair lap table has been designed for a quadriplegic at Student Support Services at Mississippi State University in Starkville, MS. The client sustained a spinal injury in a gymnastics accident in 1986 and subsequently has limited control of his arms. The client was not happy with other laps boards that were available. He was excited about having a lap board design that was customized for him.

SUMMARY OF IMPACT

This wheelchair lap table is unique in that it has a hole cut out to allow the user to install and remove it at his own convenience. Most lap tables that are on the market today must be attached and removed from the chair by someone besides the user. The mechanism that holds the table in place was adapted from a gate lock. It requires no finger dexterity. It will lock into place by just sliding the table into place through the locking mechanism. To remove, the latch can be pushed with the wrist that frees the table from its locked position.

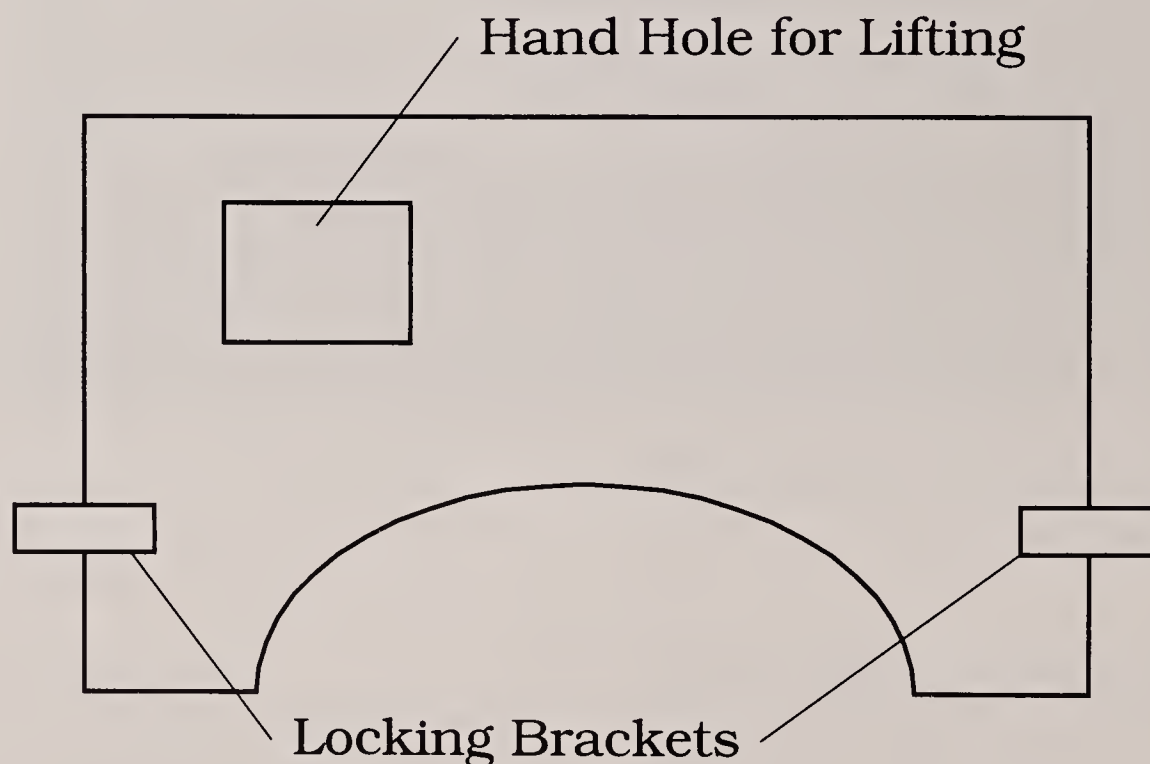


Figure 6.8. Line Drawing of Lap Table Layout.

TECHNICAL DESCRIPTION

After consideration of a number of factors such as weight, cost, strength, and impairment of front vision when in place, Plexiglas was chosen as the material for the construction of the lap table. The table is constructed of $\frac{3}{4}$ inch Plexiglas and a locking bracket. The layout of the board is shown in Figure 6.8.

The table is rectangular in shape with an arc cut out in the middle to allow the table to fit around the abdomen of the client. The locking brackets have been installed on the ends to allow the table to lock into place

on the top of the armrests of the client's wheelchair. There is a square hand hole that has been cut out in the upper left corner of the table to allow the client to insert his hand and use leverage to lift the table independently. Figure 6.9 shows the actual board, as it would fit on the wheelchair.

The total cost of the board was approximately \$75.

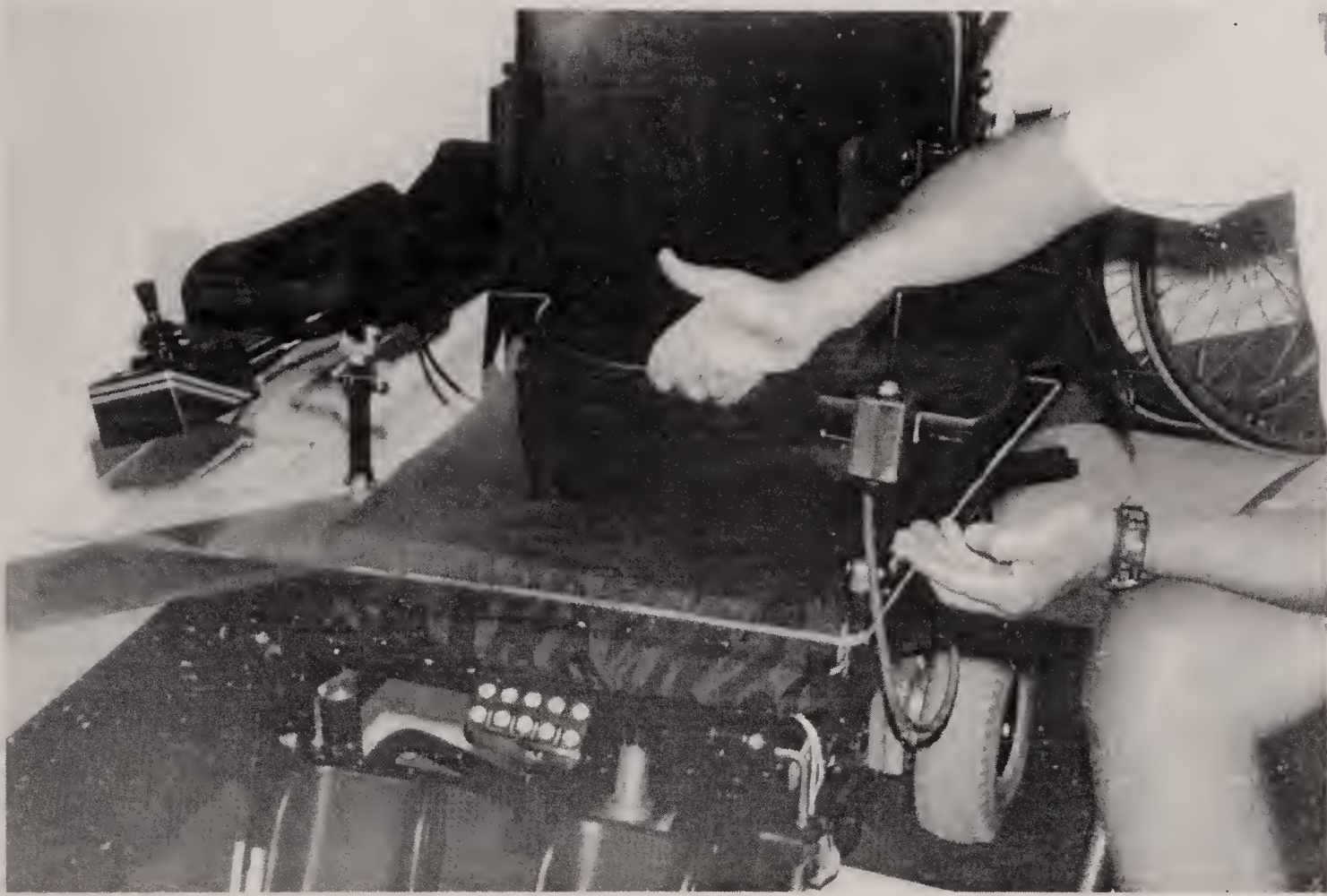


Figure 6.9. The Quad-Friendly Lap Table as it Fits on a Wheelchair.



CHAPTER 7

STATE UNIVERSITY OF NEW YORK AT BUFFALO

**School of Engineering and Applied Sciences
Department of Mechanical and Aerospace Engineering
335 Jarvis Hall
Buffalo, New York 14260-4400**

Principal Investigator:

*Joseph C. Mollendorf (716) 645-2593 x2319
molendrf@acsu.buffalo.edu*

The Wheelchair Rocker: A Devise that Provides Sensory Stimulation to Children with Multiple Handicaps

*Student Designers: Joshua J. LaPenna and Christopher J. Hausler
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

The wheelchair rocker (WR) was designed to provide sensory stimulation for children with multiple handicaps. This device is simply a motorized pivoting platform on which a wheelchair can be mounted. Once the wheelchair has been secured to the platform, it can be set into a rocking motion (see Figure 7.1). Upon completion, the WR was presented to the Center for Handicapped Children in Cheektowaga, New York. The children at this center have extremely poor motor skills. Most are not able to even sit up by themselves. Thus, they live a life of virtually no motion. Multiple handicaps frequently lead children to be bored and depressed, and to suffer from poor circulation. Ultimately, the WR is intended to give the children a sense of interaction with their environment.

SUMMARY OF IMPACT

The design criteria for the WR were defined by the capabilities of the children and the needs of the center. The physical therapists (PT) are often very busy, and are unable to spend long periods of time with any one child. As a result, the PT desired a self-operative,



Figure 7.1. The Wheelchair Rocker.

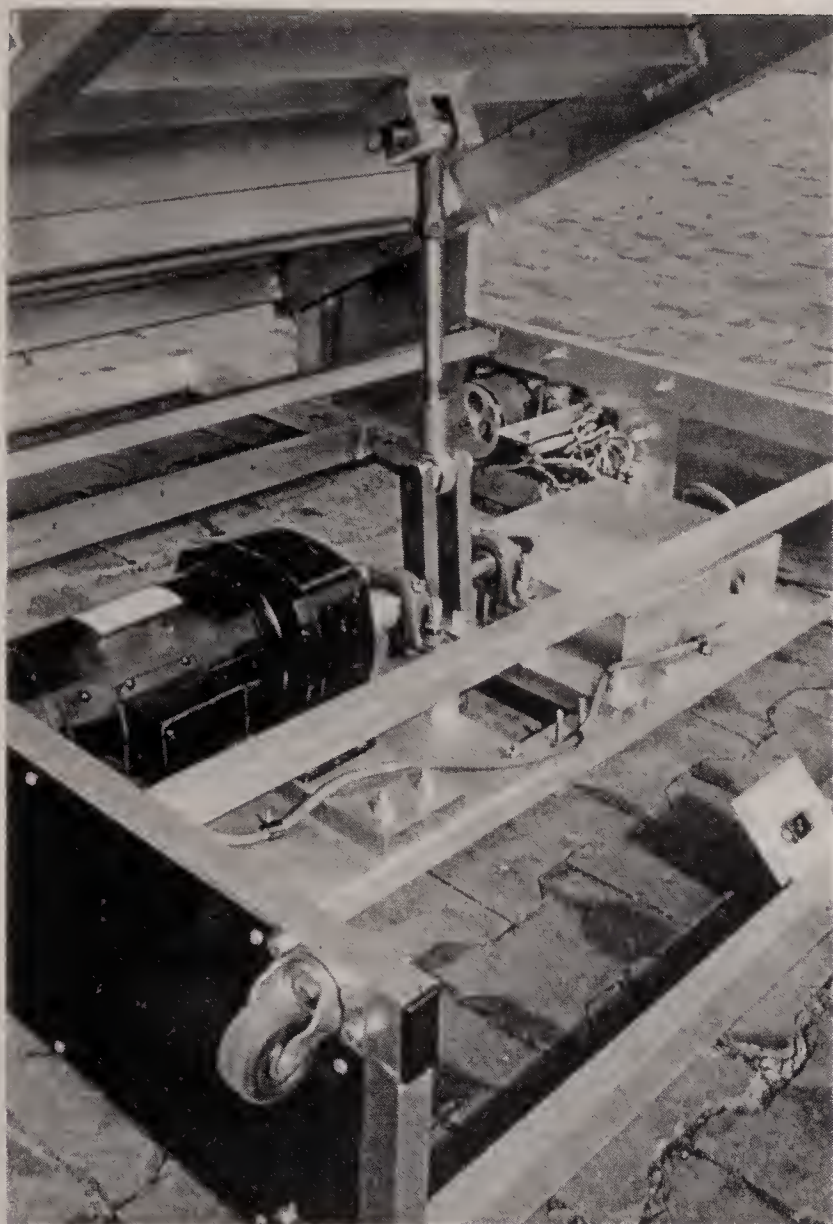
portable device that both the children and PT will feel safe using. Further, it is especially stimulating for the children as well as convenient if the children themselves have some control over the device. This not only allows the PT to leave the WR unattended for short periods of time, but also allows the children to take part in the decision-making process concerning their interactions with the environment.

TECHNICAL DESCRIPTION

The overall structure of the WR was made from anodized aluminum tubing (1 by 2 by 1/8-inch). The high strength to weight ratio, which is characteristic of aluminum, provided the necessary structural integrity and low weight requirement needed for a portable device. The frame was designed in such a way that all members come together and are welded at 90 degree angles. All additional components of the WR are fastened to the frame by bolts.

The actual rocking of the platform is accomplished by a Grashof four bar crank-rocker mechanism (see Figure 7.2). The driving link in this mechanism is powered by a 1/2 horsepower DC electric gear motor. The motor was carefully selected to assure that it would not stall under the large loads induced by the rocking of child and wheelchair. As a result of the large torque and low speed requirements, the motor is very quiet. Speed control and cost were the two main reasons a DC motor was chosen over AC. It was decided that the PT should have control of the WR's rocking frequency. This is easily accomplished by varying the voltage across a DC motor. Further, the circuit contains a rectifier that converts the AC power from the wall outlet to the DC power needed by the motor.

Aside from the motor circuit, a switching circuit was also needed. Since it is unsafe to have large amperage



going through switches, a steady-state relay was used to separate the two circuits. In this way, the motor circuit could carry five amps of current while the switches draw only a few milliamps. The WR has four switches, a power switch, a start/stop switch, a switch for the child, and a level-stop micro-switch. The power switch simply turns the machine on. This switch is placed in series with the motor. The start/stop switch is intended for the PT to use. This switch will actually set the platform into motion. The child's switch will differ from child to child, depending on the handicaps involved. Each child has a switch he or she can operate best. Thus, the WR is equipped with a universal jack to accommodate all types of switches. This switch operates in the same manner as the PT switch. The micro-switch is attached to the structure in such a way that the platform will only stop in the level position. Since all of these switches are interdependent, a series of mechanical relays were used in the control circuit to implement the logic. The control panel for the WR can be seen in Figure 7.3.

The cost of parts/material was about \$1500.

Figure 7.2. Crank-Rocker Mechanism.

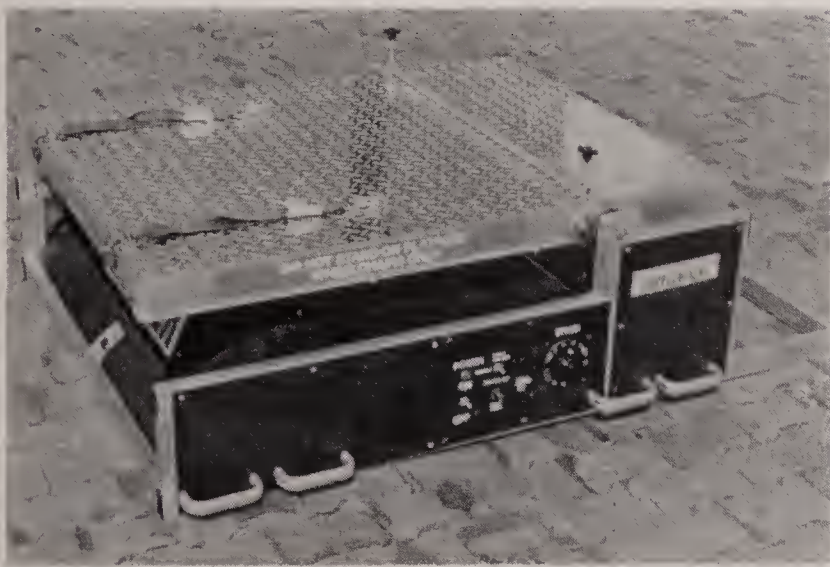


Figure 7.3. Control Panel.

Stairclimber/Walker: Apparatus for Amputee

Student Designer: Victor Katilus

Client: Eileen Sette

*Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

An assistive device was designed for individuals with one amputated leg having some residual component and one leg that is fully functioning. The residual limb must have an inseam of at least seven inches to use this device.

Although prostheses exist for this handicap, the Stair Climber/Walker can be of use for patients who, for some reason, are not wearing a prosthesis. For example, the manufacturing of an artificial leg takes time; therefore, the Stair Climber/Walker is available for interim use.

Before receiving this device, the mobility of the patient for whom this prototype was designed and manufactured was greatly hindered. She lives in a three-story flat with two sets of stairs and does not have a prosthesis. She is confined to a wheelchair and climbs the stairs by sitting on a step and dragging herself along one rise at a time. The Stair Climber/Walker is a device she can use to negotiate the stairs in her home, as well as to traverse on flat ground until she is fitted with an artificial leg.

SUMMARY OF IMPACT

A photograph of the prototype apparatus is shown in Figures 7.4 and 7.5. The patient lost her right leg above the knee and is left with a residual limb having an inseam of 8.5 inches. The device was custom made to fit her physical makeup. Since her weight will be carried by a cushioned ring that wraps around her thigh, a snug fit was essential.

The prototype is a walker that has an easily inserted extension for stair climbing. To use the device, the patient slips her residual limb (right leg) into the cushioned harness and holds on to the handle with her right hand. To walk, she steps forward with her left leg and then lifts the device using the handle and brings her right leg adjacent to the left leg. She must

take small steps to traverse, but she has become quite mobile with the apparatus.

In order to climb stairs, the patient slips the stair climbing extension on the device to accommodate the riser height of the stairs. She climbs the stairs in a way that is similar to walking. She begins by taking her first step with the fully functioning left leg up to the next riser. Then with her right hand gripping the apparatus handle and her left hand on the stairway railing, she pulls the right side of her body up while

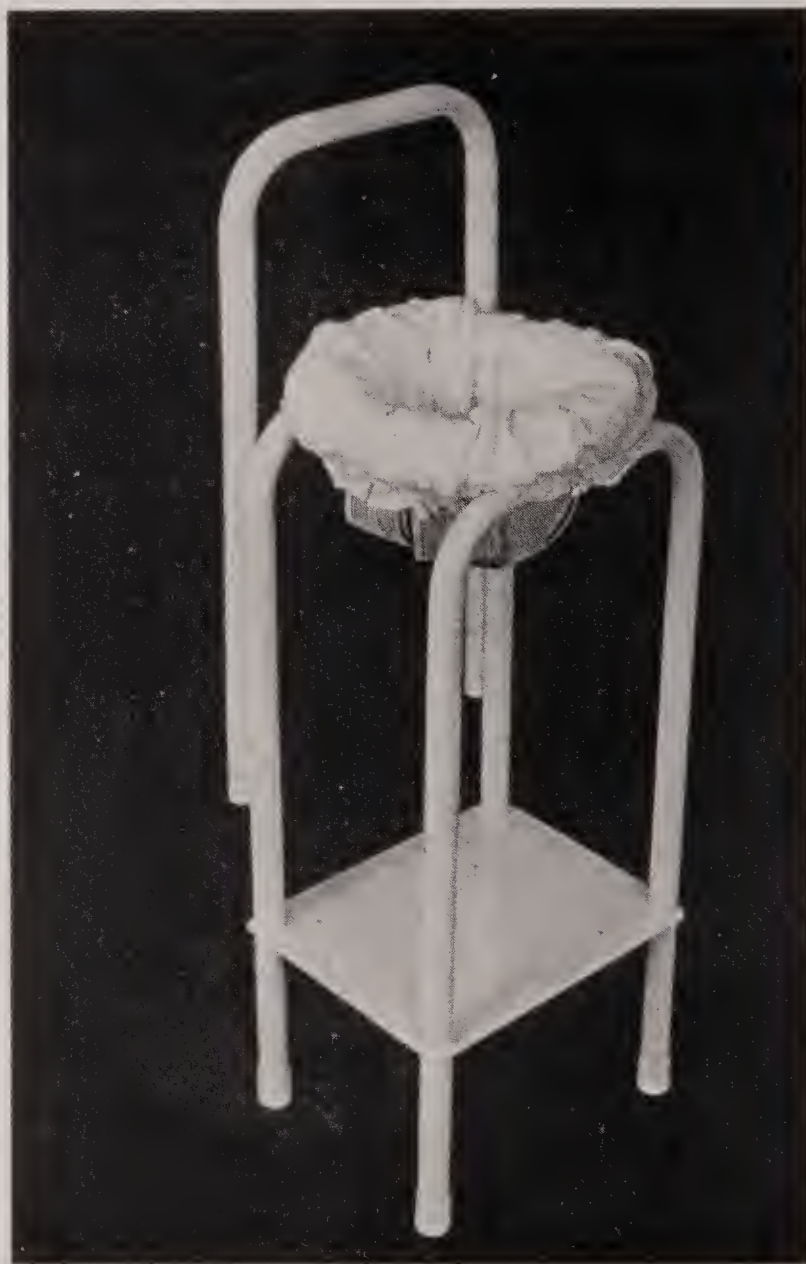


Figure 7.4. Apparatus.

straightening her left knee and planting the device on the step.

To go down the stairs, she proceeds backwards. Again, she firmly grips her right hand on the handle while holding the stairway railing with her left hand. She takes a step downward with apparatus first (her right residual limb). With the device on the lower step and flexing her left knee, she brings her left leg down to the same level as the device.

TECHNICAL DESCRIPTION

The device is lightweight (less than four pounds) and strong. The structure is made of tubing and is fastened entirely with welds. There is a lining of foam to cushion the residual limb. To change the device

from a walker to a stair climber, an extension is slipped on the bottom of the device to accommodate for the riser height of the stairs. The Stair Climber/Walker Apparatus for Amputee is an inexpensive tool that has greatly expanded this patient's mobility and improved her quality of life.

The cost of the parts and material was about \$112.

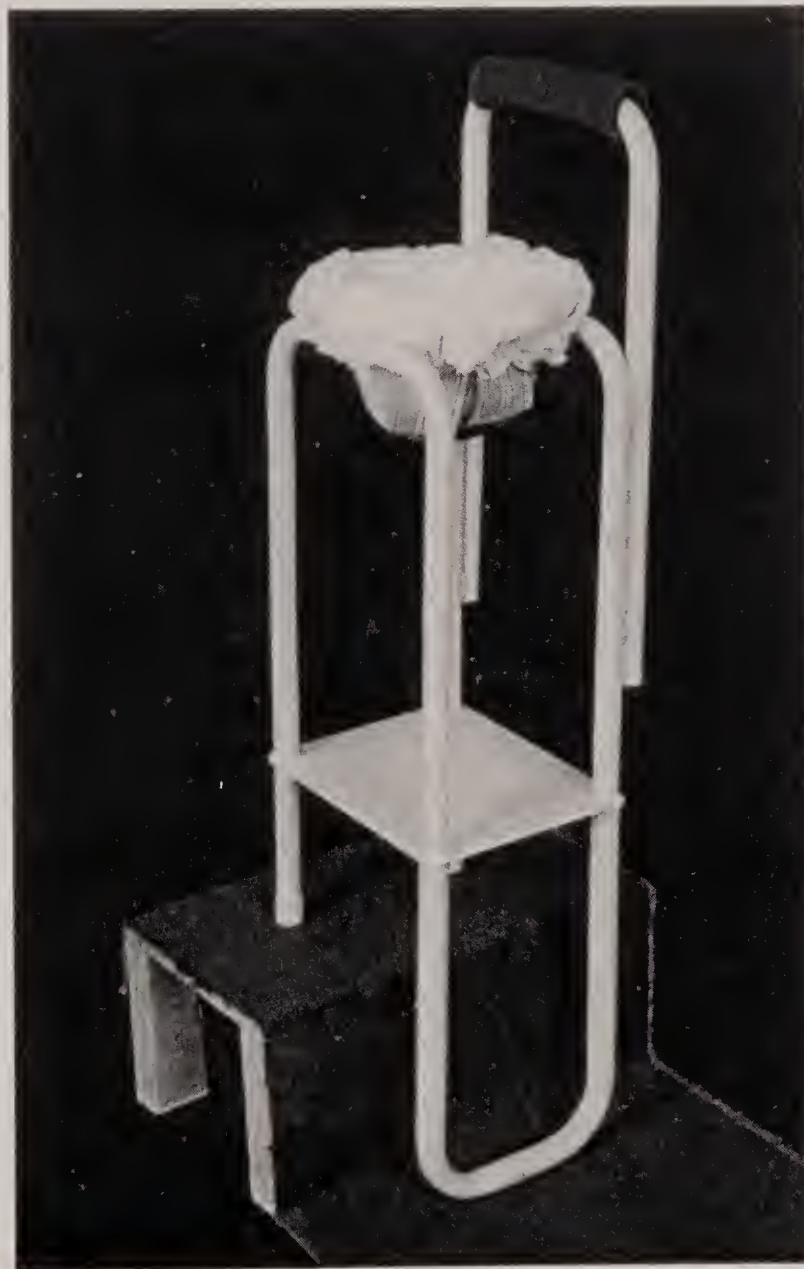


Figure 7.5. Apparatus on Step.

Geared Wheelchair Wheel: Replacement Wheel that Adds a Higher and Lower Gear to Wheelchairs

Student Designers: Brian Bodkin, Kurt Blemel, Matthew Keehan III

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

Wheelchair users are often faced with steep handicap accessible ramps and hills that are difficult to ascend. Some users lack the arm strength to propel a wheelchair effectively even over level surfaces. Some just want to go faster in their wheelchairs. The Geared Wheelchair Wheel fulfills these needs by providing higher and lower gears for increasing speed or ascending inclines.

The design consists of a three-speed gearing system incorporated internally into the wheel hub. The handle normally utilized to propel the wheelchair now acts through the gearing system to drive the wheel at different rates. The user needs only to engage the gear shifter on the wheelchair armrest to change gears. Also, the geared wheel is mounted in place of the normal wheel, with all other aspects of the wheelchair remaining unchanged.

SUMMARY OF IMPACT

The Geared Wheelchair Wheel will increase the mobility of any wheelchair operator. One specific application context is the sport of wheelchair racing. A higher gear would increase the maximum speeds of the wheelchairs, possibly revolutionizing the sport.

Another important application involves climbing ramps and hills. A normal wheelchair can only be propelled at a one-to-one gear ratio, with the handle rigidly attached to the wheel rim. Therefore, the user has no mechanical advantage in ascending steep grades. The Geared Wheel provides a lower gear, enabling the user to conquer these obstacles with less force.

The lower gear also allows people with limited arm strength to drive the wheelchair by themselves.

Additionally, the Geared Wheel retains the one-to-one gear ratio for standard wheelchair operation.



Figure 7.6. Mounted Wheel.

TECHNICAL DESCRIPTION

The Geared wheel functions in essentially the same manner as a three-speed bicycle. In fact, the prototype pictured in Figures 7.6, 7.7 and 7.8 used the rear hub from such a bicycle. Modifications to the hub were made in order to fit the needs of the wheelchair user. These alterations included:

- Adjusting the coaster brake mechanism to allow movement in reverse. Otherwise, the

wheel would lock when the user tried to propel themselves backward.

- Moving the gear shifting device (which was initially located on the handle side of the wheel) to beneath the wheelchair. This allowed the wheelchair with the Geared Wheel to retain approximately the same width as the original wheelchair. The hub axle had to be drilled and fitted with a specially machined steel cylinder to accomplish this task. The cylinder, threaded onto the protruding end of the axle, holds the shifting mechanism in place with a second set of threads.

The steel cylinder also acts as the mounting post for the Geared Wheel. The outer surface of the cylinder was threaded to allow quick bolted attachment to the wheelchair mounting bracket. Since a bike hub is held fixed at both ends of its axle, the Geared Wheel's single connection presented the risk of having the axle

bend or break. The cylinder effectively increased the strength of the axle. A needle bearing was also placed between the hub and cylinder to reduce resistance.

Moving the handle connection from the wheel rim to the hub was necessary to drive the three-speed transmission. A steel circular plate was machined and welded to the hub where the normal bike sprocket would be located. A ½-inch galvanized steel conduit was bolted in three places on the plate and then attached to the handle ring. Three additional sections of conduit added strength to the handle geometry.

The Geared Wheelchair Wheel is an effective and relatively inexpensive assistive device with numerous applications.

The cost of the parts/materials was about \$160.

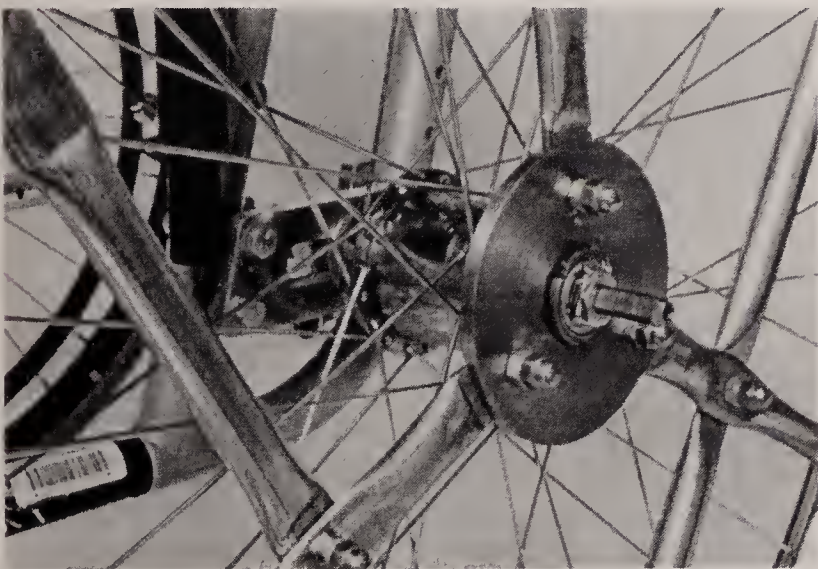


Figure 7.7. Close-up of Geared Wheel Mounting.



Figure 7.8. Close-up of Geared Wheel Hub.

Remote Door Opener: A Device that will Unlock and Open a Door for a Disabled Person with Limited Motor Skills

Student Designers: Keith Schroder, Michael Jansen and Neal Ginsberg

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

For many people with disabilities, conventional doors can be a problem. Keys can be hard to handle when a person's hand-eye coordination is diminished. An automatic door opener was designed for a specific door on the campus of the State University of New York at Buffalo. The device allows its user to gain entrance to his work area without the assistance of co-workers. A remote controlled device will enable him to unlock and open the door at the push of a button.

SUMMARY OF IMPACT

A device was built to allow remote controlled access to a room. The device causes no interference with the existing locking mechanism or doorknob. The device could be manipulated slightly to fit on most doors.

TECHNICAL DESCRIPTION

Industrial strength door openers currently exist but are not inexpensive. The remote device presented here is inexpensive, small, and allows regular-keyed access by other occupants. The door opener components are shown in Figure 7.9.

The door originally had a top mounted pressured hinge that normally kept the door in a closed position. The hinge was replaced by a pressured hinge that acts to keep the door open. This means the door must be manually shut. When unlocked, the hinge forces the door to the open position, allowing access to the room.

The locking mechanism on the door is always locked from the outside and always unlocked from the inside. The door originally could be unlocked from the outside with the use of a key. The installation of the remote opener now allows entrance by using the remote switch. The unlocking mechanism is installed on the inside of the door (Figure 7.9). A wooden



Figure 7.9. Door Opener Components.

clamp-like handle is secured to the door handle so as to not interfere with manually turning the actual doorknob. The wooden handle is connected to fishing line running horizontally across the door. Midway across the fishing line a motor is mounted to the door. Attached to the motor is an arm that rotates clockwise when the motor is activated. The arm pushes the string, pulling the wooden handle, causing the

doorknob to turn. The door is then opened and the remote user has access to the room.

The cost of parts/materials was about \$70.



Figure 7.10. Door Opener Mounted.

Modified Ambulator: A Walker that Allows for One-Handed Collapsibility and Incremental Weight Adjustment

Student Designers: David Eynhorn, Nathan Kyser, Thomas Sass
Client Coordinators: Robin Tirado, M.S., Ed.; Center of Assistive Technology (CAT)
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400

INTRODUCTION

This project addresses two main issues: 1) the need of a disabled person to collapse a walker without removing his or her hands from the handles and 2) the need for a lower center of gravity for a walker to provide a greater sense of stability. Improvements over existing walkers were necessary as no commercially available walker provided one-touch collapsibility with a convenient location for activation. In addition, such walkers are generally made to be as light as possible, which conflicts with many persons' psychological need to "feel" stable. The additional weight should satisfy this need while allowing for adjustments to suit each individual.

SUMMARY OF IMPACT

The modifications were made with a particular user in mind. The client has limited mobility of the right side of her body, while the left side of her body is fully functional. Her attempts at using a quad-cane have been unsuccessful due to her loss of balance on several occasions. Also, using a conventional walker did not provide this client an adequate sense of stability. The client is presently going through rehabilitation in an effort to re-enter the workplace. Mobility (getting around the office and to and from the car) plays a key role in reaching her objective of employment. The modifications should assist her with her goals. A photograph of the modified ambulator is shown as Figure 7.11.

TECHNICAL DESCRIPTION

The project consists of two components:

- actuation mechanism (with safety device), Figure 7.12;
- incremental weights, Figure 7.13.



Figure 7.11. Modified Ambulator.

The actuation mechanism modification entailed use of the existing single-button mechanism along with a device that activates it. The mechanism consists of a brake handle, cable, and lever/bracket. As a precautionary measure, a safety device was also incorporated into the brake handle to prevent accidental collapse of the walker. The safety device

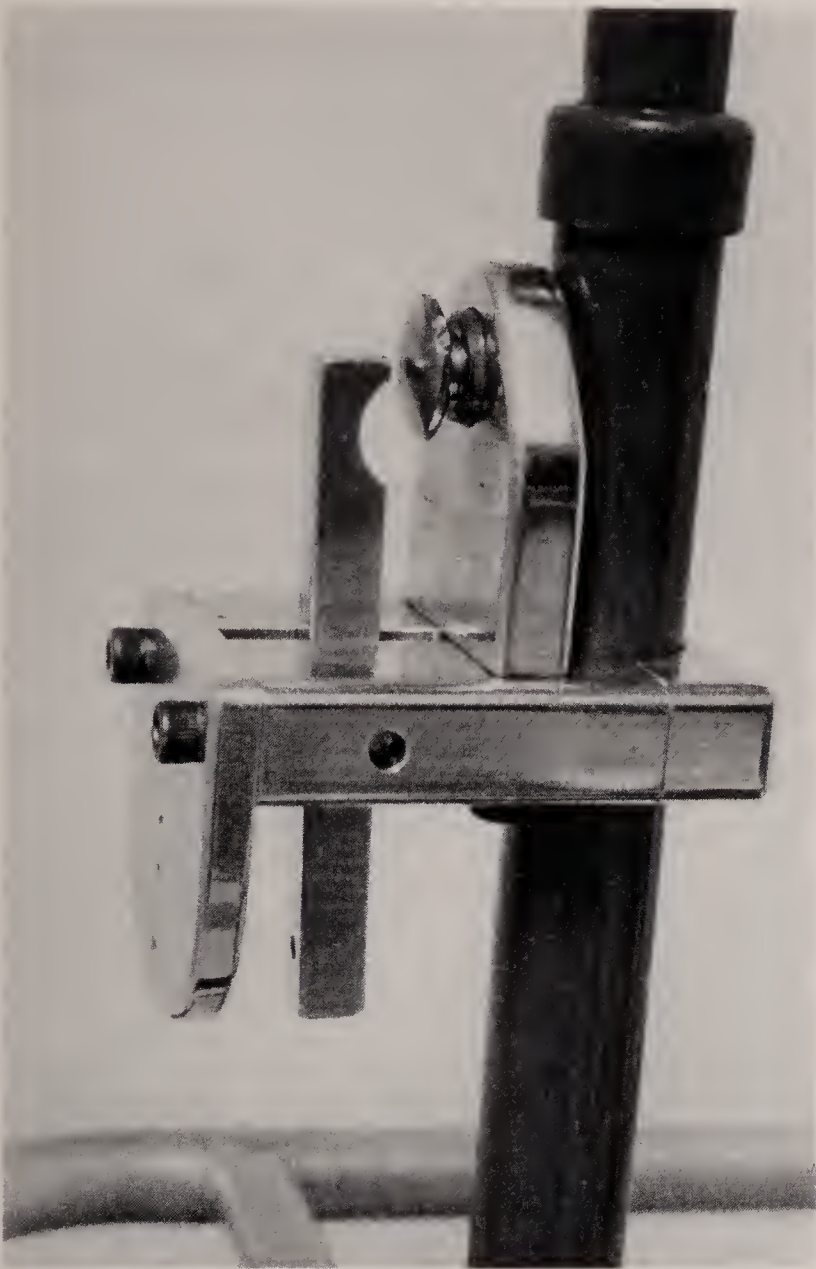


Figure 7.12. Actuation Mechanism.

requires the user to depress a safety button while pulling on the brake handle. Once the handle is released, the safety mechanism locks the brake handle in place. The motion of the handle is translated through the brake cable to the lever/bracket. The lever/bracket depresses the existing button (which

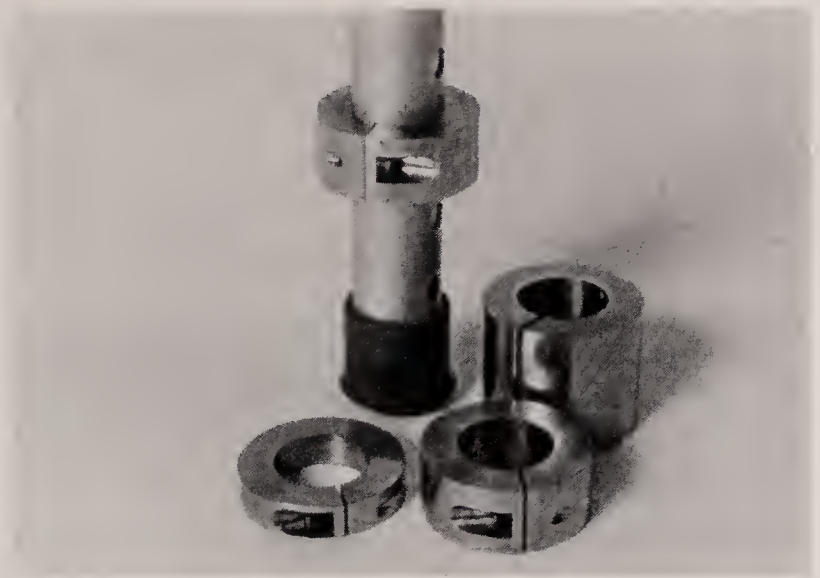


Figure 7.13. Incremental Weights.

allows for collapsing of the walker) through a simple lever action. The lever and bracket are both made of aluminum that provides corrosion resistance and an aesthetically pleasing appearance

The incremental weight is made of stainless steel bar stock machined to fit the legs of the walker. Stainless steel was chosen because of its high density and corrosion resistance. The weight sizes are one pound, half pound, and quarter pound. The added weight can be adjusted from zero to ten pounds. The weights are clamped in place with a tightening bolt. The tightening bolt will also deter the user from unnecessary and unsupervised removal of the weights. By nature of the adjustable height of the walker the legs are easily removed, therefore, allowing easy removal of the weights.

The cost of the parts/materials was about \$130.

The Versi-Grabber: A More Versatile Assistive Reaching Device

Student Designers: Richard Donegan, Christine Stokolka and Steven Ward

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

There are many assistive reachers on the market today. None, however, offers more than a straight member with a gripping device on the end. With current reachers, if an elderly person who has had hip surgery wishes to retrieve a can of soup from a high cupboard, he or she can only reach straight up. In order to pick up the can a 90-degree bend in the reacher is required. Also, current reachers tend to serve only one function. Often a patient must purchase several reachers for various needs.

The Versi-Grabber is a much more versatile device that allows 180-degree rotation of the gripping end with respect to the straight member. The Versi-Grabber is also designed to have interchangeable heads so that only one reacher needs be purchased (See Figure 7.14).

SUMMARY OF IMPACT

The Versi-Grabber will allow disabled people to easily reach places and objects that other reachers cannot. The simple act of getting a can of soup from a shelf is important to a disabled person who wishes to be as independent as possible.

The device will also eliminate the need for several reachers. Several attachments can be designed to be compatible with the trigger end such as back and leg scratchers, a flexible or straight gripping mechanism, a shoe horn, a bath sponge, and so on.

TECHNICAL DESCRIPTION

The device was constructed from a current reacher used for picking up objects. A flexible steel tube similar to that of a goose neck lamp was used to provide the desired flexibility for the gripping attachment as seen in Figure 7.15. The reacher has a non-standard rectangular cross section so a special coupling end was designed from standard size



Figure 7.14. The Versi-Grabber.

cylindrical tubing. The rest of the couplers could then be easily made from standard size aluminum tubing.

The quick disconnect coupler was designed so that a person with arthritic hands can operate it. As shown in Figure 7.16 a large knobbed screw and slot arrangement is used to provide easy detachability. The large knobbed screw is threaded into the male side of the coupler. Each attachment has a female end like that in Figure 7.16. The components slide



Figure 7.15. Flexibility of Design.

together and the screw is tightened preventing rotation or axial separation between them.

To operate the grabbing attachment a control string is needed. When the trigger is pulled, the string is also pulled and activates the gripper. A piece of stiff plastic tubing through which the string passes was fixed into the attachment end. The stiff tubing allows for easy insertion of the thread through the hole in the quick connector on the trigger side. To facilitate the quick detachment design, a hook and loop arrangement on the string allows it to be easily disengaged.

The following are the simple steps required to change attachments on the Versi-Grabber. First, tension in the string is released by closing the gripping mechanism.

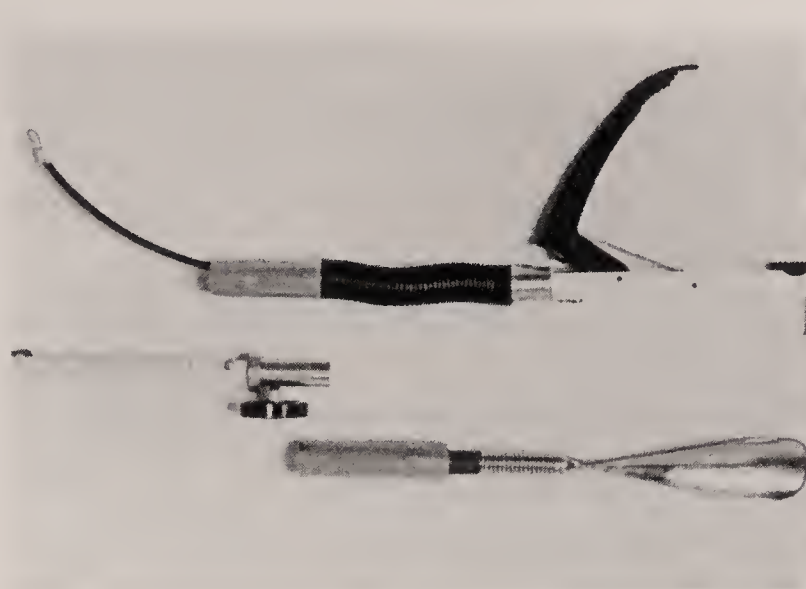


Figure 7.16. Quick-Connect Coupler.

Second, the string is disengaged by simply unhooking it from the loop. Third, the large knobbed screw is loosened and the attachment is pulled off. To put another attachment on, the procedure is reversed. The entire process takes only a few seconds and can be done by someone with little manual dexterity.

Another handy feature is a telescoping arm brace. By loosening the knob on the bottom, the pole can be adjusted for any arm length.

The cost of parts/material was about \$30.

Variable Height Computer Table: Allows Computer Height to be Easily Adjusted to Accommodate Children with Different Disabilities

Student Designers: Steven B. Everett and George C. Michalko

Client Coordinator: Mary Ann Saloman, Center for Handicapped Children

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

At the Center for Handicapped Children, there are children with varying degrees of disability. Some of these children are confined to wheelchairs, while others are lying down. Some use standers that allow them to stand in a somewhat erect position. A computer table was designed so that it could be easily adjusted in height to accommodate each of these children. Since the device is being used in a classroom setting, it must be reliable, durable, and extremely safe. The unit must be portable, with wheels and a depth small enough to allow it to fit easily through doorways. To ensure the acceptability of the device, it should also be aesthetically pleasing.

This device consists of a three walled study carrel, in

which the tabletop can be moved up and down using a motor driven rack and pinion system.

SUMMARY OF IMPACT

Using the Variable Height Computer Table, the staff at the Center will be able to easily adjust the height of the table by simply pushing a switch. This will save time and effort, and reduce the risk of damage to the computer.

TECHNICAL DESCRIPTION

The three main components of the table are the three sided study carrel frame, rack and pinion drive unit, and electrical system.

The study carrel frame was built using a laminated



Figure 7.17. Variable Height Computer Table.

particleboard. This particleboard met the strength requirements and the laminated surface made it pleasing to the eye. An aluminum frame was built around the base of the wooden frame for additional strength. Castor wheels for the unit were mounted onto the aluminum frame.

The drive unit consists of a motor, a worm and worm gear, steel shafts, two pair of miter gears, and four racks with pinion gears. The motor drives a short shaft with the worm and worm gear. Using miter gears, the short shaft drives the other shafts, which run the full length of the table top. At each end of these long shafts is a pinion gear. When the motor is engaged, these four pinion gears crawl along the four racks, raising or lowering the table top. Because these pinion gears are connected by solid shafts, and powered by the same motor, they provide safe, stable support for the table top (Figure 7.18).

In the electrical system, a momentary up-down switch was used to activate the motor. A 90 V DC

permanent magnet motor was used because it is small, has reversible operation, and met the calculated torque and speed requirements. Power for the motor is provided by passing AC current through an AC-DC rectifier.

Because the racks were mounted to the side walls of the study carrel, there was a possibility that if the side walls were to separate, the pinions could come out of the racks and the table top could drop. A guide system was added to eliminate this risk.

The variable height computer table provides safe, stable support of the table top and computer system, and makes height adjustment very easy. The table meets the needs of the Center for Handicapped Children, and will ultimately save a great deal of time and effort.

The cost of parts and materials was about \$790.

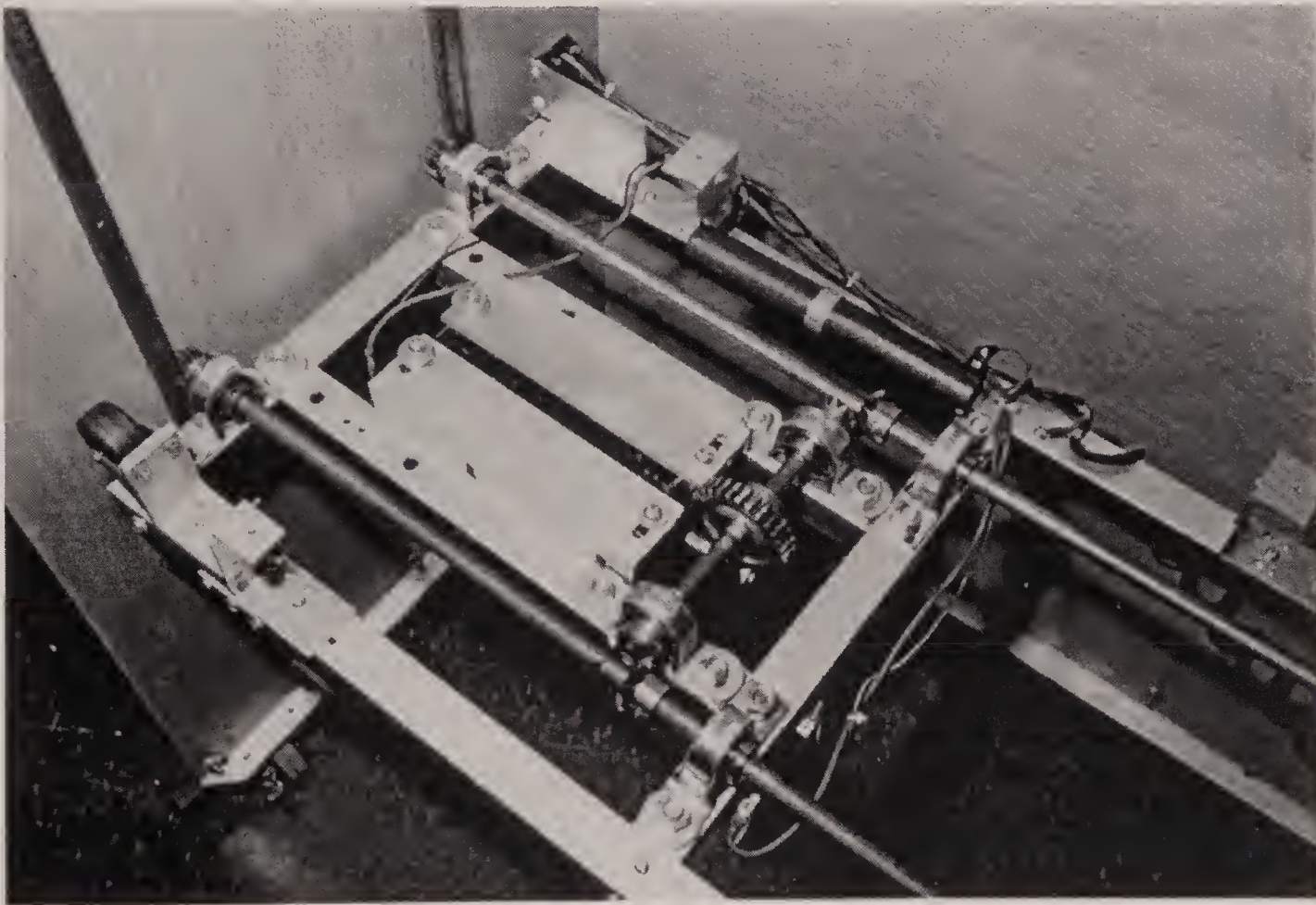


Figure 7.18. Motor Drive System.

Anti Collision System

Student Designers: Timothy S. Lane and Martyn J.C. Berry
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400

INTRODUCTION

The inspiration for this project came from observing a blind youngster who, particularly in unfamiliar environments, needed to be warned as he strayed near obstacles (such as furniture). Upon hearing a warning, a call of "hands [-up]" or "careful," he raises his hands to investigate the hazard. The basic intent was to construct a device that would remove the need for the presence of a sighted supervisor, thus providing greater independence to both the youngster and his parents. It seems obvious that a device of this sort could be of use to blind people of all ages, possibly as a substitute for the traditional white cane.

The design utilizes an ultrasonic transducer similar to those found in the auto focus mechanism of a Polaroid camera. The transducer is mounted remotely from a processing unit that, through an earphone, generates an audible indication of a hazard. In the prototype, the transducer is mounted on the head. The processor is contained in a sturdy box enclosed in a pack. This gives hands-free operation in the same manner as a miner's head lamp. Other configurations, such as hand held type (flashlight style), a button type, or a hat type may be more desirable.



Figure 7.19. System Components.

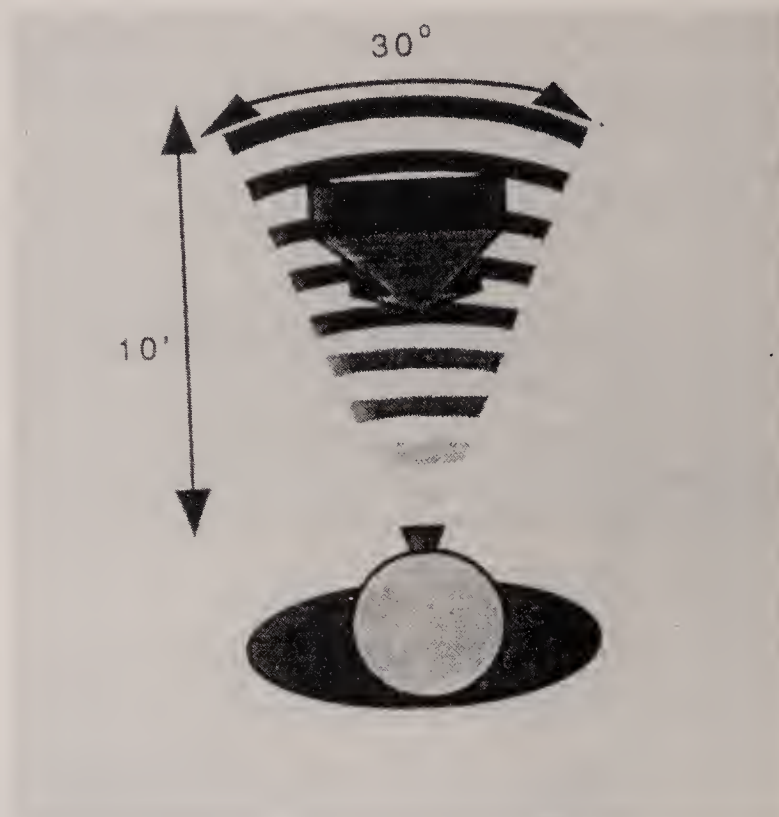


Figure 7.20. Cone of Detection.

SUMMARY OF IMPACT

It is hoped that the anticollision system will enable blind persons to enjoy a safer, more independent, and more confident interaction with their surroundings.

The prototype had two modes of operation. By momentarily depressing a button on the unit the user may elect either to hear a tone with a pitch that is proportional to the distance of the transducer from an obstacle, or just to hear the tone as an obstacle is approached; these modes of operation enable the user to use the device to sense their surroundings or simply as an alarm of an oncoming hazard.

It was felt the device could be introduced to blind children as a toy.

TECHNICAL DESCRIPTION

The device was physically divided into two discrete units, the ultra-sonic transducer and the processor. In operation, a pulse is transmitted toward a target and

the resulting echo is detected. Using the processing unit the time elapsed between the initial transmission and the echo detection can be converted to distance, based on the speed of sound. In this arrangement the transducer works both as a loudspeaker to transmit the outgoing signal and as an electrostatic microphone to receive the echo. The outgoing signal takes the form of a high frequency inaudible "chirp", lasting for about half a millisecond. A 400-volt signal is applied across the transducer each time a chirp is transmitted. Thus, the transmitter had to be carefully packaged in a robust and non-conductive high density polyethylene casing. This casing measures approximately 2-1/8 inches in diameter by 1.0 inch and was attached to the elastic headband. The ranging circuit was mounted separately with the processor.

In order to install this onto the EEPROM on the computer board, algorithms were designed and

arranged in an HC11 assembly code using a PC text editor. Following completion of the basic program, a button was added to allow the user to toggle between the two modes of operation.

The transducer and processing unit was connected using a heavy-duty 0.25-inch phono cable. A standard earphone jack was used so that any style of earphone can be used. The earphone volume was set using various resistors. A 0.25-inch jack for a battery charger socket and on/off switch was also used.

The cost of parts/material was about \$226.

ACKNOWLEDGEMENTS

Roger Krupski provided guidance and assistance with computer programming and electronics. Kenneth Peebles and the workshop team provided help in the manufacture of the sensor casing.



Figure 7.21. Headband Embodiment.

Collapsible Chair for a Walker

Student Designers: Todd Chalmers, Mark Messinger and Timothy Speyer

Client Coordinator: Linda Chalmers, Hospice Buffalo, Inc.

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

A client of Hospice Buffalo requested that a seat be installed on his walker. In addition, he wanted to have wheels added to the front legs. These modifications were necessary because he frequently became exhausted when walking considerable distances. The addition of a collapsible seat on the right side of his walker will allow the client to sit whenever he desires. The addition of front wheels will aid in mobility and reduce the effect of the added weight of the collapsible seat. Hospice nurses stated that safety and weight were critical design parameters. It was important to ensure that the seat be very easy to set up and use, as the client has limited physical ability. Furthermore, the design was not to interfere with the primary function of the walker, to help users walk more efficiently. In summary, a seat attachment was designed such that it did not impede the client's walking but when needed could easily be used. These design criteria had to be met while collapsibility was still preserved.



Figure 7.22. Walking Configuration.

SUMMARY OF IMPACT

The basic idea of incorporating a seat onto a walker offers the client a greater degree of independence and eliminates the worry of fatigue. This project will have a significant impact for physically challenged people. As before, the client will be able to collapse his walker for easy storage. But now, instead of walking to a bench, he can merely position the attached seat with one hand. The attachment fulfills the needs of the client and satisfies the design criteria. Because the seat height was designed to be adjustable, this design can be equally appreciated by people of various sizes who share this client's limitations.

The seat attachment was designed for use on walkers of a similar type, with minimal additional machining, thus making it a viable option to consider for an assembly line process. While maintaining safety, the additional weight gain is less than five pounds.



Figure 7.23. Sitting Configuration.

TECHNICAL DESCRIPTION

The attachment is made of standard one-inch aluminum tubing. It connects to the walker using an aluminum pivot mount and collar. The seat frame will then pivot out from the side of the walker on the

aluminum collar. The seat platform is constructed of two triangular pieces of plywood that connect to the frame with U-clamps. Modified hinges connect the two pieces along the fold. The seat cushion is composed of vinyl-covered rubber foam. In case of maintenance or long-term storage, the entire attachment frame can be fully disassembled.

The attachment has the following advantages:

- It is convenient and easy to install.
- It can be positioned with one hand. Also, it can be installed and removed with the use of a screwdriver.
- It is not obtrusive. The attachment adds eight inches to the total width of the walker, preserving its ability to pass through doorways. Additionally, the position of the attachment allows the walker to remain collapsible.

- It is aesthetically pleasing. The frame is composed of tubing similar to that of existing walkers. The seat covering is also color-coordinated to match the walker.

The cost of parts/materials was about \$75.

ACKNOWLEDGEMENT

Kenneth Pebbles and the other technicians at the University of Buffalo Machine Shop provided input and assistance in machining. Bernie Fix and Gerry Mertzluft at Apple Rubber Products provided help in the machining of various parts. Hospice Buffalo Inc. generously donated a walker identical to that of the client.

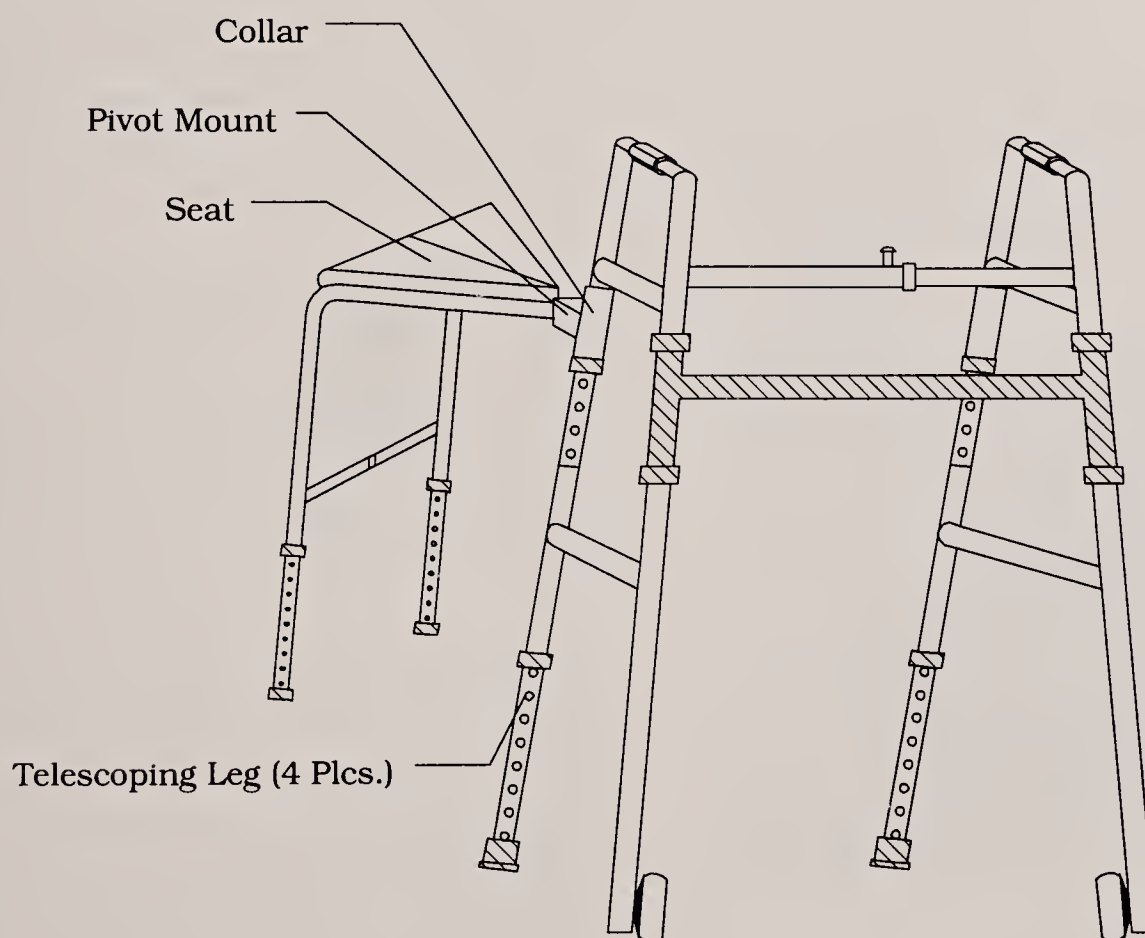


Figure 7.24. Fully Assembled Seat on Walker.

Easy-Access Cause-Effect Toy

Student Designers: Bjorn DeBear, Manish Patel and Sarfraz Naina

Client Coordinator: Dr. Shelly Lane, University of Buffalo Occupational Therapy Dept.

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

Many children with multiple disabilities have poor motor skills. This makes it hard for them to learn cause-effect relationships and slows their cognitive development.

Dr. Shelly Lane, at the University at Buffalo Occupational Therapy Department, understands the needs of such special children. Dr. Lane feels that the toys possessed by her department offer very few sensory stimuli. The stimuli the toys do provide generally cannot be turned off selectively by the therapist if they overwhelm a client. Furthermore, the children treated by the department have a great deal of difficulty using many toys because of their poor motor skills.

This project was undertaken to address this problem by constructing a cause-effect toy. The challenge was to modify an existing toy to create desirable sensory stimulation, a toy that could be activated by switches and deactivated selectively by a therapist.

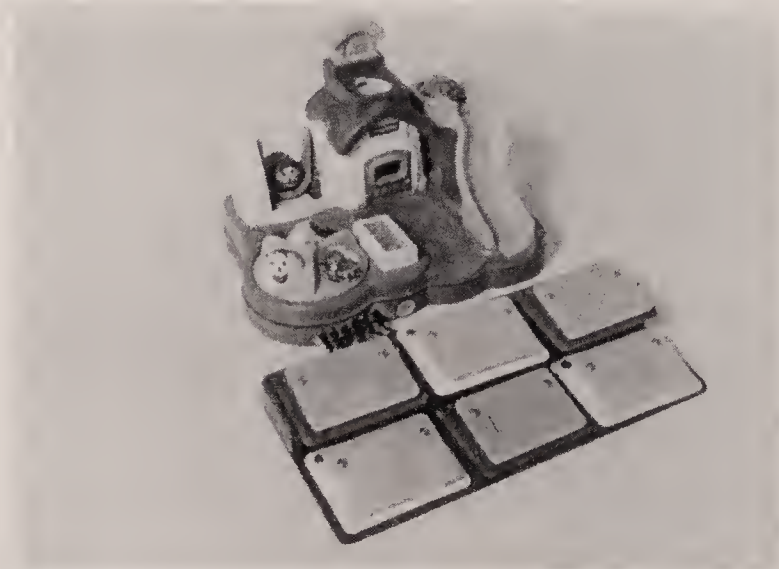


Figure 7.25. Front View of Toy.

SUMMARY OF IMPACT

The toy used was an improvement upon an existing Fisher-Price play set called the "Roll-Around Playground." This improvement allows occupational

therapists to teach young children with multiple disabilities cause-effect relationships. The improvement makes this possible through easy-access plate switches connected to electrically-powered play features.

The easy-access switches allow children with multiple disabilities to turn on the following effects: 1) a swing that swings back and forth; 2) a merry-go-round which spins; 3) a door that swings open and stays open as long as its switch is depressed; 4) a bell tower that lowers, rings a bell, and causes a toy person to drop through a chute; 5) a wading pool that lights up; and 6) a speaker that plays a short melody.

The swing, merry-go-round, door, and bell tower components existed before the improvement, but could only be manipulated by children possessing good motor skills. The improved version causes these components to move automatically through the use of electric motors and solenoids.

TECHNICAL DESCRIPTION

The "Roll-Around Playground," contained the following moving components: swing, merry-go-round, door and bell tower. The improvement on this product allows these components to move by electric power, and adds a light component and a sound component to the toy.

All components are activated through the depression of easy-access plate switches. The swing is caused to move by a crank in a gearbox linked to a three-volt motor. The merry-go-round is caused to move by a shaft running from a gearbox linked to another three-volt motor. The door is caused to move up a rocker-rocker mechanism linked to a six-volt solenoid. The bell-tower is caused to move by a cable linked to a cable linked to a 120V AC solenoid. The wading pool light is a bank of nine 3V LED pairs. The LEDs comprising the pairs are connected in series, so the overall voltage drop across the component is six volts.

The speaker and the circuitry producing the music are from a "Micro-Jammer"® keychain toy. The 120-volt bell tower solenoid is connected in parallel with a three-volt adapter and a six-volt adapter. This circuit receives current directly from a wall outlet plug. The three-volt adapter in turn provides power to the two motors and the music circuit, which are all connected in parallel. The six-volt adapter provides power to the door solenoid and the wading pool light which are also connected in parallel. The easy-access plate switches shorting the circuits are plugged into the jacks located in the front of the toy.

The modified toy will help occupational therapists empower young children with multiple disabilities by

demonstrating that they can have an effect on their environment. The plate switches are operable by children with very poor motor skills, and the play features are activated the moment corresponding switches are depressed, clearly displaying tangible cause-effect relationships

The cost of parts and materials was about \$320.

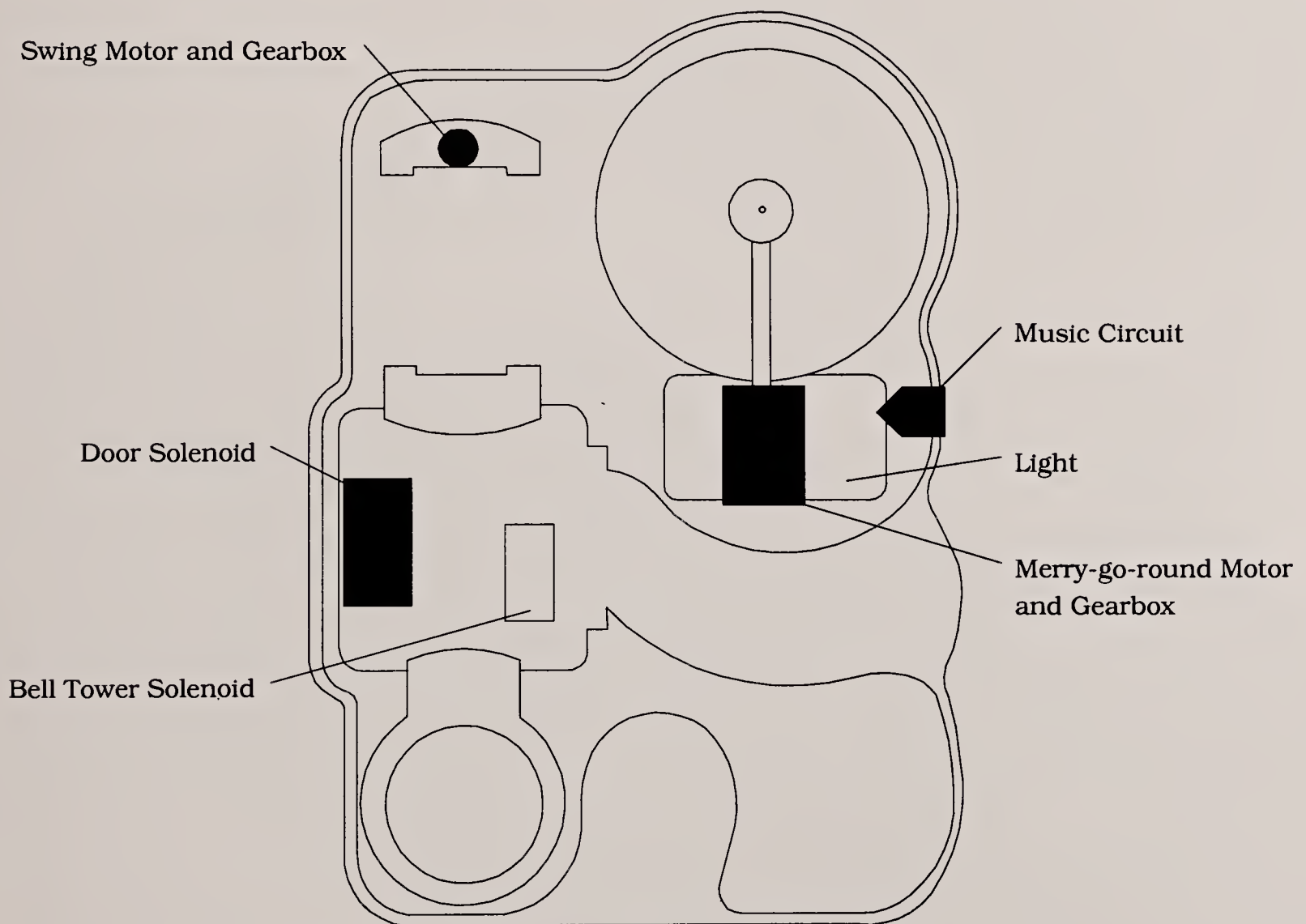


Figure 7.26. Internal Components of Toy.

Paper Money Identifier for Persons who are Blind

Student Designers: Eric Lieberman, Nick Nikolaidis, Ka Wai Hung, and Pok Chong

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

In order for blind people to gain independence they must overcome many barriers. One of these barriers is identifying paper money. When making purchases, blind people have no way of ascertaining whether or not they receive the correct change. This device will not only assist them in receiving proper change, but also with any other type of monetary transactions.

The device entails a laser scanner that scans a section of a bill into a microcomputer. The microcomputer then compares this scan to prescanned bills. When it finds a match within a certain confidence limit, it outputs the value of that bill in a series of beeps. For instance, a twenty dollar bill would make the device give two low pitch beeps and one high pitch beep. The low pitch beeps correspond to the first digit, two and the high pitch beep corresponds to the second

digit, zero. Similar logic is used for ones, fives, and tens.

This device is only a prototype. In order to make the device practical it must be condensed to pocket size. However, this will require the production of customized parts that are expensive and are time-consuming to produce.

SUMMARY OF IMPACT

It is expected that the Paper Money Identifier for the Blind (PMIFB1) will increase the confidence of blind people in making monetary transactions and promote independence. To use this device, a blind person will turn it on, place the bill in the device, and pull the bill out slowly. Once a match is found the device will output the bill denomination.

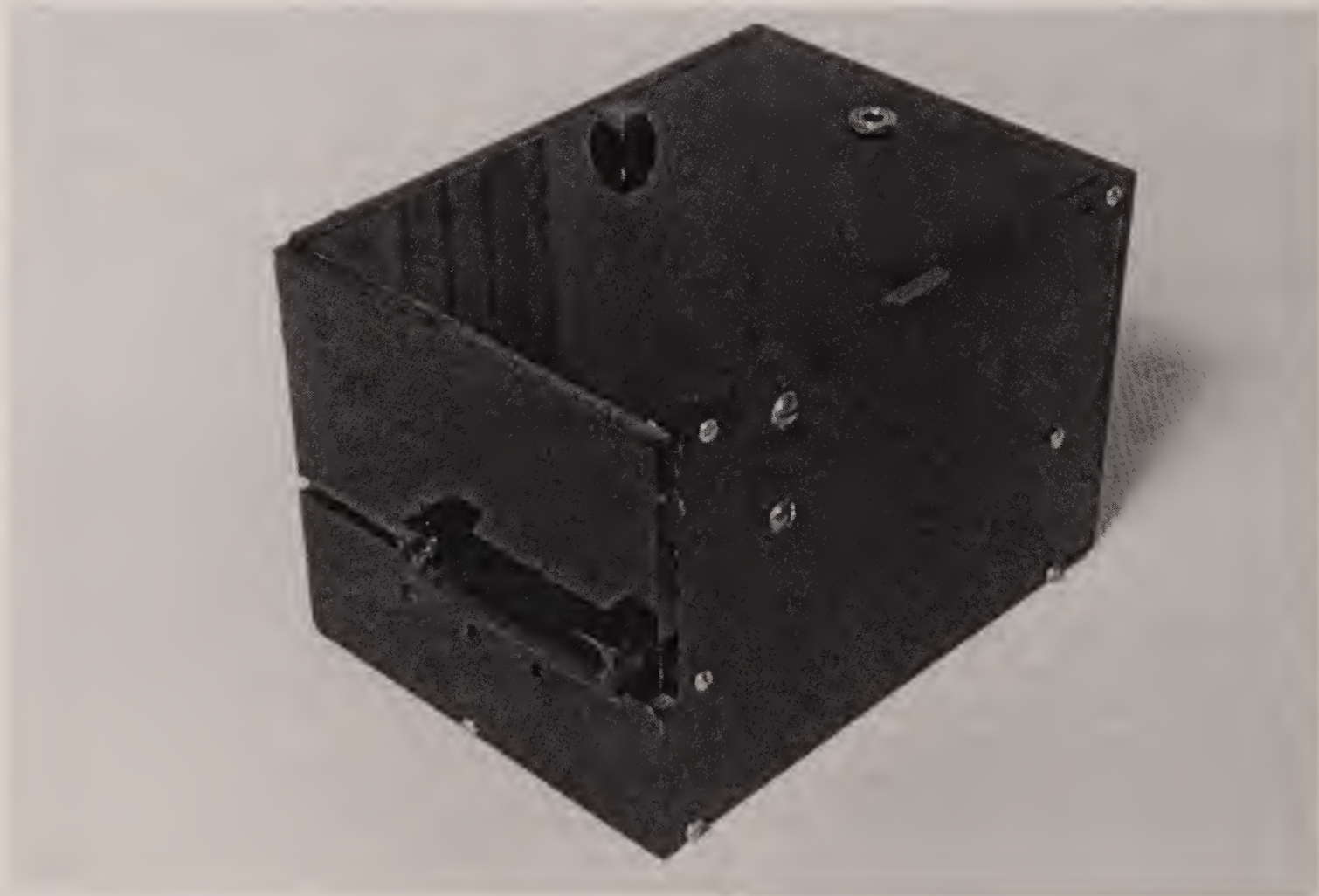


Figure 7.27. Sealed Unit

TECHNICAL DESCRIPTION

The device consists of a laser module, a photodetector array, a microcomputer, a motor, a mirror, and its outer casing. The outer casing includes a track where the money is to be inserted by the user.

This laser module includes a laser with a lens on the end, which permits the laser to be focused. It also contains the laser circuitry, which regulates the voltage going to the laser. The laser is a visible light five-milliwatt laser. It is positioned at a fifteen degree angle in the mirror with respect to the track.

The mirror is 10 mm diameter circular front surface mirror. It is mounted on the motor so it can guide the laser over the paper money.

The photodetector array is composed of eight detectors angled downward at the money and one detector angled upward facing the mirror. The detectors are used to transmit data to the computer based on light and dark spots on the money as either high or low value bits.

The microcomputer is the Motorola M68HC11. Its purpose is to use the laser, detectors, and the motor to scan in data from a bill. The microcomputer will then compare it to prescanned data and output a value using an IC controlled piezoelectric buzzer when a match is found. The microcomputer uses a sophisticated program to perform this process.

The cost of parts/materials was about \$508.

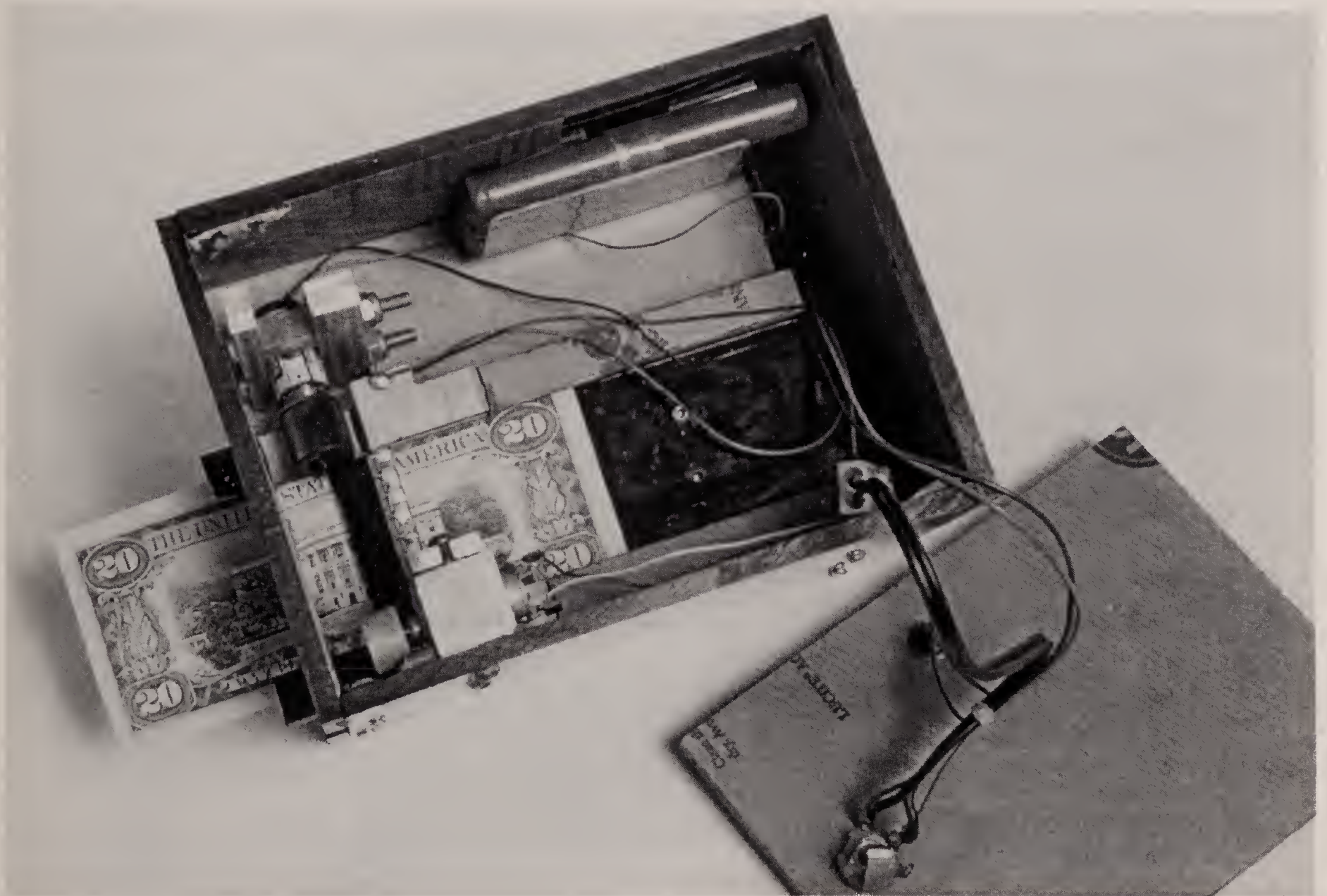


Figure 7.28. Exposed Unit.

Single Hand Gear and Braking Mechanism For One Handed Bicycle Operation

Student Designers: Jason Vaughan, Mark Dunmire, David Bongiovanni and Scott Homac

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

This project affects people with limited use of one hand. A person with such limitations may find it hard to ride a standard bicycle safely because brake and shifting levers are located on both sides of the handle bars. In such cases, it is safer to have all controls located on the side of the usable hand. The current design is to be used with the right hand on a 21-speed mountain bike. The design was built for high performance capabilities, but is versatile enough to be used by a rider of any level.

SUMMARY OF IMPACT

Current market products of this nature do not exist, making this a one of a kind unit. The hope is for this device to increase the rider's potential through

decreasing limitations of impaired riders. The prototype may also inspire others to pursue improvements with similar designs.

The applications of this device could evolve beyond an assistive device for impaired persons. It may be that control of all shifting and braking functions from one hand is beneficial for all who like to ride bicycles. For now, the design and ease of use is more practical for persons with unilateral impairments.

TECHNICAL DESCRIPTION

The design integrated currently available standard brake and shifting levers. Two sets of levers were combined into one unit. The top set of levers control the front sprocket derailer, moving the chain through three gears and the front brake. One top gear lever

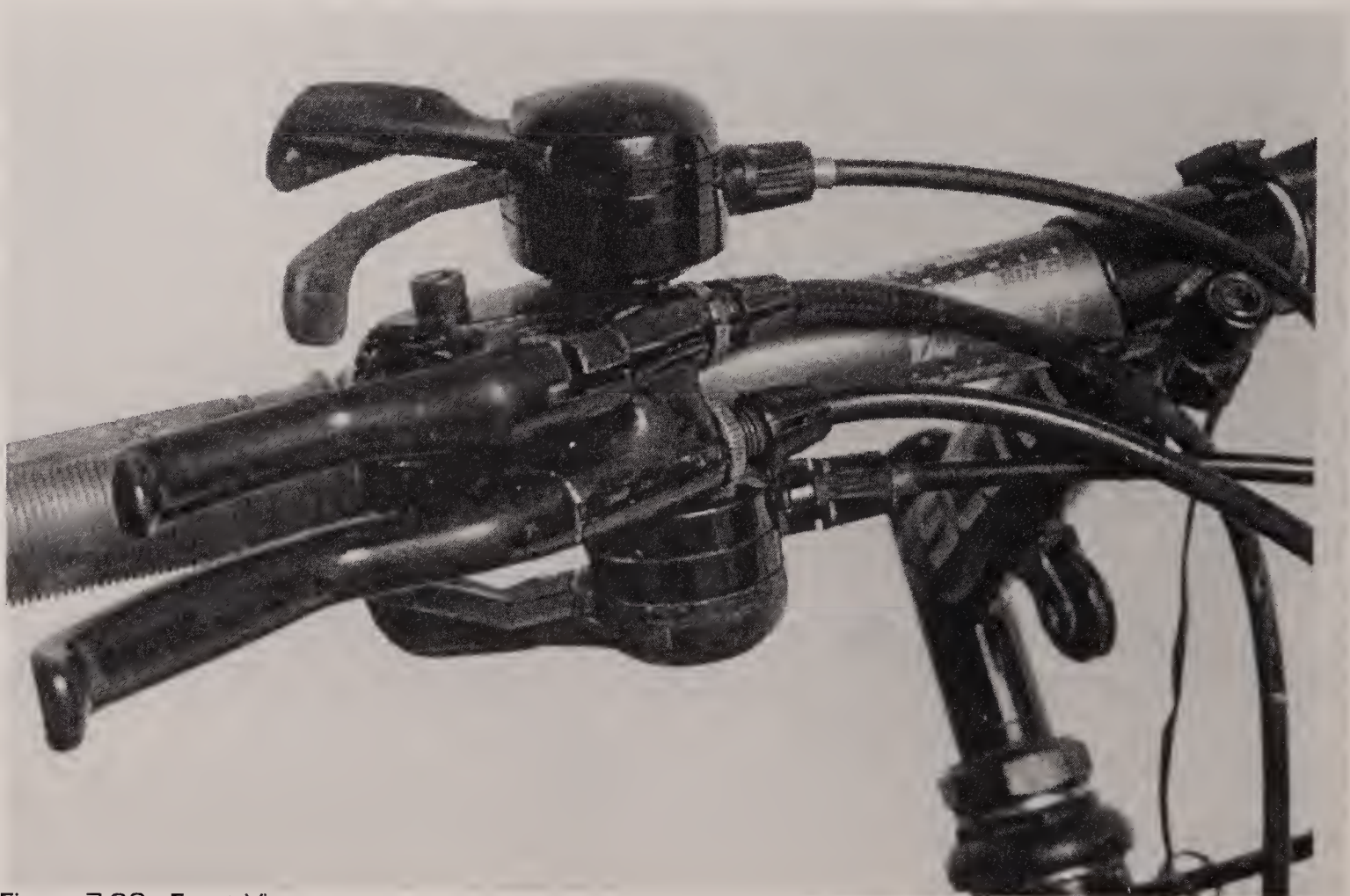


Figure 7.29. Front View.

moves the chain up the sprocket sizes and the other down. The same occurs for the back derailleur, where one lever moves the chain up the gear cog and the other down. In this case the far bottom lever moves the chain up through seven different gears.

The unit was made by pressure-fitting available brake and shifting levers together with metal pins. First, the two pieces were cut and shaped by removing excess metal. This was done so that the front brake and derailleur levers could be laid into a position on top of the back levers. Holes were then drilled into each piece where pins were used to pressure-fit the other together. A spacer was used to provide the correct clearance between the pieces. Once together, a metal epoxy was used to fill the void and provide strength.

After hardening, the part was shaped to be contoured and physically appealing.

All levers have cable adjusters at the lever base. This eliminates the need for minor adjustments accomplished by resetting the cable in the derailleur or brake clamp. Both brake levers also have adjusting screws where the position of the levers can be manipulated. This was incorporated so that the levers may be offset from each other, making them more accessible. The need for adjustability was such that the unit could be more versatile for each individual rider.

The cost of parts/materials was about \$109.



Figure 7.30. Back View.

Wheelchair-Height Adjuster To Raise A Handicapped Individual to Another Plane

*Student Designer: Clifford J. Solowiej
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

This project addresses a serious problem faced by nurses and nursing assistants. After an individual is confined to a wheelchair, other people must assist in the vertical transport of the handicapped individual. Incorrect lifting may lead to painful back injuries.



Figure 7.31. Close-Up Of Cylinder, Connector, and Rear Wheel.

SUMMARY OF IMPACT

There are no known existing devices that perform the same functions that the Wheelchair-Height Adjuster



Figure 7.32. Wheelchair Up-Position.

does. Hopefully, hospitals will find this type of invention to be a beneficial tool.

The Wheelchair-Height Adjuster allows an individual to be easily transported in the vertical direction. The operation of the device is simple. By pumping the pump, the wheelchair rises, and by twisting the release valve, the wheelchair lowers.

TECHNICAL DESCRIPTION

The device is composed of an assembly of four hydraulic cylinders with a twelve-inch stroke. The front two cylinders have round, half-inch diameter rods and the rear two hydraulic cylinders have hex, half-inch diameter rods. The hex rod keeps them from rotating. Other parts include a hand pump with a stroke-volume of two cubic inches, a relief valve, two flow divider valves, an oil reservoir, four mounting braces, and two rearwheel connectors. The four mounting braces mount directly to the wheelchair in the respective places of the wheels. The cylinders are end mounting and screw into the mounting braces. Lock nuts are then screwed on to make sure the cylinders do not come unscrewed. The

respective wheel connectors are screwed onto the ends of the rods of the cylinders and then the wheels are attached. The pump is mounted on the right side so that the handicapped individual can pump up the wheel chair or else the nurse can pump it up. The reservoir is mounted on the left side. Hydraulic hoses connect the pump, the cylinders, the relief valve, and the flow divider valves. The purpose of the relief valve is to set a maximum pressure inside the hydraulic assembly. Finally, the flow divider valves ensure that the wheelchair will rise evenly.

The cost of parts/materials was about \$1336.



Figure 7.33. Wheelchair Raised Position.

Passage Detection System that Alerts Staff when Patient Leaves Care Unit

Student Designers: Kurt Hacker, Jarred Osborne, Henry Zhao and Yuan Lai

Client coordinator: Carol Hacker, Erie County Home and Infirmary

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

In busy nursing homes, such as the Erie County Home and Infirmary, the staff is limited and therefore unable to supervise patients at all times. Patients with dementing illnesses such as Alzheimer's disease are especially problematic as they tend to wander and get lost within the hospital complex with no way of telling someone they are lost. A simple solution would be to lock the exit doors to the unit. Due to state laws this is not possible. The current device will

give nurses the warning they require to retrieve patients before they leave the unit, reducing the need for constant supervision.

SUMMARY OF IMPACT

The main goal of this device is to retain the patients within a residential unit, where they will remain safe. The staff will also spend less time searching for missing patients.



Figure 7.34. Finished Unit In Case.

TECHNICAL DESCRIPTION

The device is comprised of three main components: the transmitter, the receiver, and the wireless microphone. The transmitter and receiver are from a commercially available "invisible fence" animal containment system. The transmitter consists of a control box that sends a low frequency radio signal through a closed wire loop attached to the box. This loop is mounted around the exit doors of the nursing unit. The control box is plugged into a standard 110-volt, wall outlet.

The receiver, which picks up the radio signal sent through the wire, has two exposed metal posts on its surface. When the receiver unit, worn by the patient, passes through the doorway and crosses the wire, the receiver is activated. When this occurs, a small electrical current is sent to the metal posts. This current sounds a small beeper placed in series between the posts. The beeper continues to sound until the receiver leaves the transmitter's range, which is approximately six feet on either side of the wire.

The wireless FM microphone is packaged together with the receiver. When the beeper is activated, the microphone broadcasts the sound to a FM radio located at the nurse's station or carried by a nurse. The microphone is easily tunable to frequencies between 88 and 108 MHz and has a range of over 400 feet.

The receiver and microphone are packaged together in a lightweight, shock-resistant leather case that can be clipped to a patient's pants or looped through a belt.

The user was quite satisfied with the design as it provided a less expensive alternative to commercially available systems, while at the same time effectively controlling the problem of patient wandering.

The cost of the parts/materials was about \$200.



Figure 7.35. Receiver, Microphone and Carrying Case.

Computer Monitor Shelf with an Electronically Adjustable Height and Depth For Use By Handicapped Children

Student Designers: Jir-Shyr Chen, Jeffrey S. Parker and Shu-Sheng Yu

Client Coordinator: Barbara Kopko, Cattaraugus BOCES, Olean, NY

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

When using computers, handicapped children are often hindered by the constraints imposed upon them. Some children find it difficult to view the monitor at a fixed position, especially those in wheelchairs. Those who are taller require the monitor to be elevated. Wheelchairs also prevent the people from moving close to the monitor. Consequently, wheelchair users require the monitor to be adjusted forward.

A motorized adjustable shelf was created to allow the user to adjust the computer monitor's position (see Figures 7.36 and 7.37). To effect the vertical motion, a simple scissors jack is employed and a rack and pinion is used to produce the in/out motion. Sliding tracks are used to stabilize the shelf and to guide the movement. To adjust the monitor, the user need only press any one of four large push-buttons. Because the users are mainly handicapped children, several safety precautions are added. A protective covering surrounds all moving components, and a master switch allows teachers to prevent misuse of the shelf.

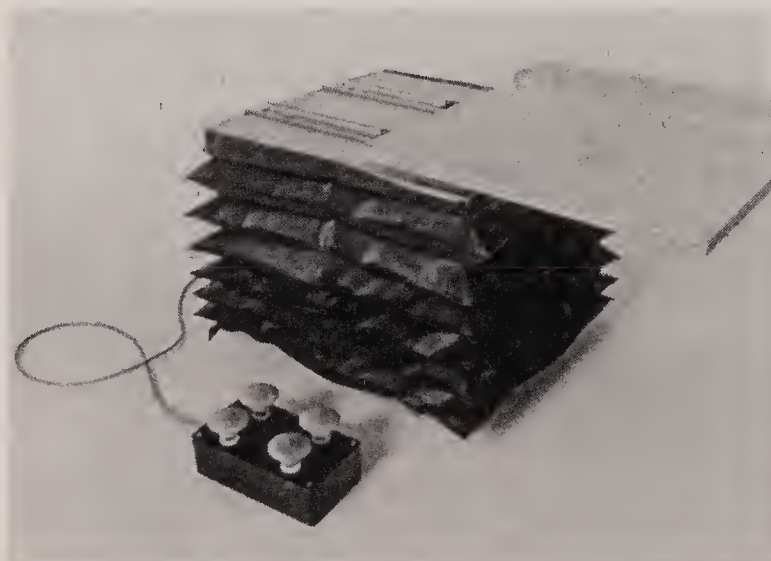


Figure 7.36. Finished Unit In Up and Down Position.

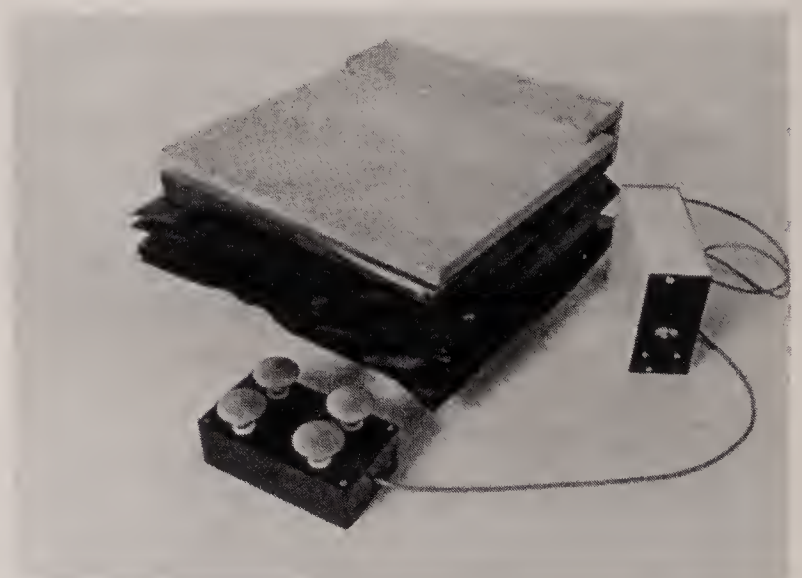


Figure 7.37. Finished Unit In Down and In Position.

SUMMARY OF IMPACT

The shelf should allow a wider range of people better access to the computer. This also reduces the need for buying several computer workstations to accommodate each student.

An alternate use of the adjustable shelf should be as a cause-effect device. The movements actuated by the push-buttons are noticeable enough for the child to learn the cause-effect relationships.

TECHNICAL DESCRIPTION

Because no existing device could be found to satisfy the client's needs, a new design was created. The design consists of a mechanical component and an electrical component.

The compressing/depressing of a pair of scissors jacks actuates the up/down motion. A large flange attached to a drive screw and motor will power the motion. As the motor turns, the flange will either compress or decompress the scissors jacks, thereby raising or lowering the platform, respectively.

A rack and pinion attached to a second motor will move the upper shelf in and out. The movement of the upper shelf is constrained by the sliding tracks. Also, the tracks provide support for the upper shelf.

To limit the range of motion of the shelf, mini-limit switches are used. The limit switches will stop power to the motors when triggered. From the fully compacted position, the shelf can raise 10 inches and extend outward 10 inches.

All of the components are enclosed within a neoprene bellows. The bellows is custom-made to fit the design.

For the electrical component, the main concern was safety. A simplified schematic showing only the up/down portion can be seen in Figure 7.38. K1a and K1b are relays powered by the "up" switch and K2a and K2b are relays powered by the "down" switch.

The schematic for the in/out motion is the same. Basically, when a push-button is pressed, one of two relays is triggered. This will cause the motor to turn in the appropriate direction. Should two conflicting push buttons be pushed (i.e., up and down, or in and out), the system will not operate.

All of the electrical components are housed in a box located at the back of the shelf. A master switch located on the box allows the supervisor to stop the movement of the shelf at any time. Also, the limit switches open the circuit when triggered, thereby stopping motion.

The cost of the parts and materials was about \$200.

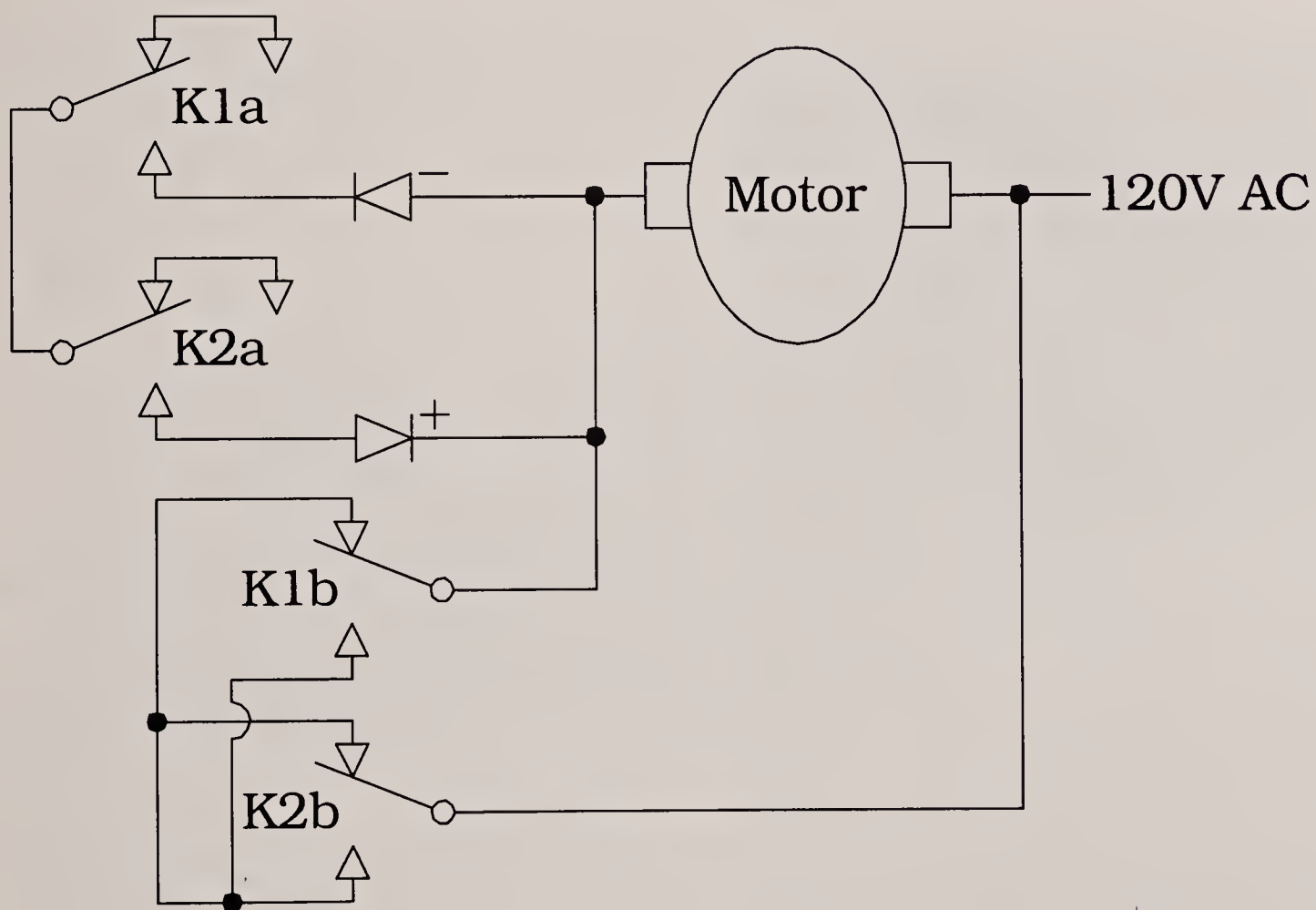


Figure 7.38. Simplified Schematics.

Light Sensor for Blind People: A Device to Enable Blind People to be more Aware of their Surroundings

*Student Designers: Mitch H. Lee and Meng Ung
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

The objective of this project was to design and build an assistive device to enable blind people to "sense" the brightness of their surroundings, so that they will be safer in dark places.

Several aspects were considered to ensure that the design was practical and reliable. The device had to be lightweight, small and rugged, so that a blind person could carry it all the time. It was important that it be affordable as well as easy to operate.



Figure 7.39. The Light Sensor.

SUMMARY OF IMPACT

The Light Sensor was successfully built. It weighs about 1 ounce. It is packaged in a plastic cylinder (with a height of 1 inch and radius of 1/2 inch). The plastic case makes the device hard to break. The device is small, lightweight and rugged. The device is operated by an on/off switch that makes it very easy to use.

The Light Sensor enables a blind person to "sense" the brightness of his or her surrounding by emitting different sound pitches corresponding to the intensity

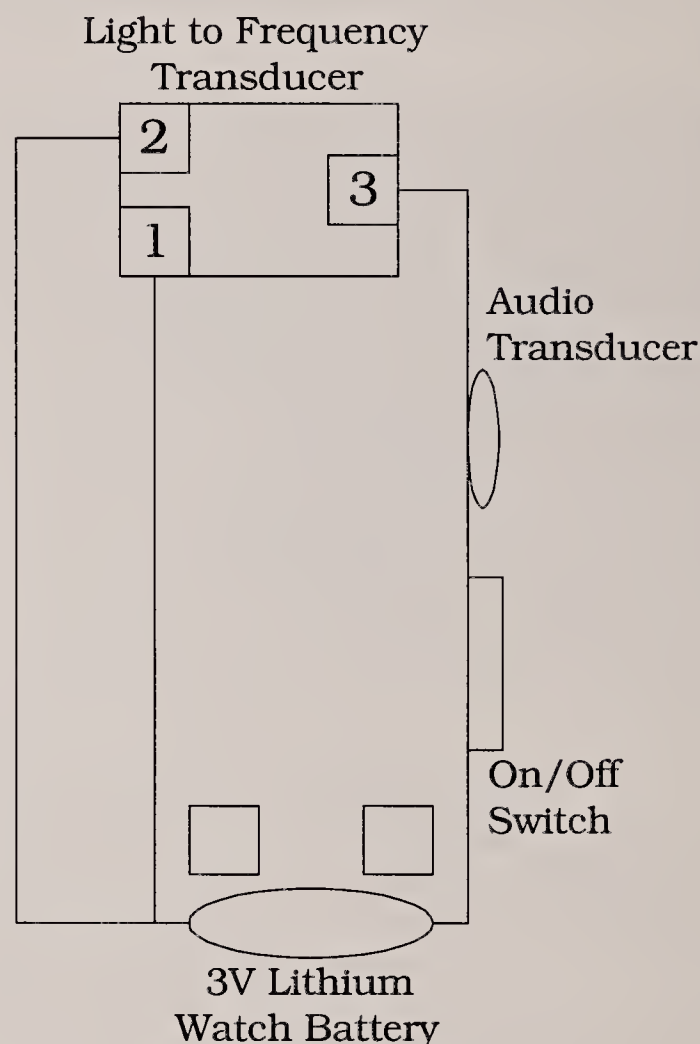


Figure 7.40. Circuit Diagram Of The Light Sensor.

of the light. The brighter the surrounding, the higher sound pitch the device produces. Through the sound pitch, a blind person can tell how bright the surroundings are and thus how well other people could see him or her. He or she may take extra safety precautions when the sound pitch from the device is low, so that possible danger can be avoided.

TECHNICAL DESCRIPTION

The Light Sensor mainly constructed in two parts, the circuit design and the package case design. For the circuit, a TSL235 Light to Frequency Converter was

used to convert light frequency to audio frequency. An AT17 Audio Transducer receives the audio signal and generates sound. A 3V Lithium watch battery powered the device and an on/off switch regulated the electrical current.

In normal daylight, the circuitry produces ultrasonic sound, which is inaudible. To detect normal daylight, the light surrounding the device had to be dimmed to produce sound within an audible range. This was done by concealing it in the package case. The case had three chambers, the top one holding the Light to Frequency Converter. The chamber was sealed from light by a removable cap.

The only light source was from the center hole in the cap. The hole diameter was chosen to allow the correct amount of light to enter, so that the audible audio range matched the light intensity range of daylight. The hole could be made smaller to

accommodate brighter daylight or larger for indoor use. Two top chamber caps were made to be used for typical outdoor and indoor light conditions, respectively. The second chamber held the Audio Transducer and the on/off switch. The third chamber held the battery. It was covered by a cap at the bottom. The cap was removable to allow for changing of the battery.

The cost of parts and materials was about \$15.



Figure 7.41. Light Sensor With Indoor and Outdoor Caps.

Anti-Slip Tread with Engaging Cleat for Use with Assistive Walking Devices in Inclement Weather and Variable Terrain

Student Designers: James Militello, Matthew Sass, and Michael Zampogna

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

The objective of this project was to design and build a cleat to minimize the amount of slip regularly experienced with assistive walking devices in inclement weather and variable terrain. Existing assistive walking devices serve the user well on a multitude of indoor surfaces but are less effective outdoors, often slipping, thus increasing the chances of falling. With this in mind, a new design was focused on two main aspects: optimum traction on outdoor surfaces such as loose gravel or ice, and the versatility to be used indoors without damaging existing surfaces such as wood or tile floors. Ergonomics, ease of use, and aesthetic characteristics

were also taken into consideration to produce a mechanism that was as user friendly as possible.

SUMMARY OF IMPACT

The anti-slip tread with engaging cleat was successfully built to reduce slippage in inclement weather and variable terrain. It was equally reliable and stable for indoor use. The unit combines a movable stainless steel cleat with a rubber anti-slip tread to enhance traction. For indoor use, the cleat can be retracted allowing only the anti-slip tread to contact the floor, eliminating damage to floor surfaces. The cleat is easily retracted using a lightweight hand control lever.

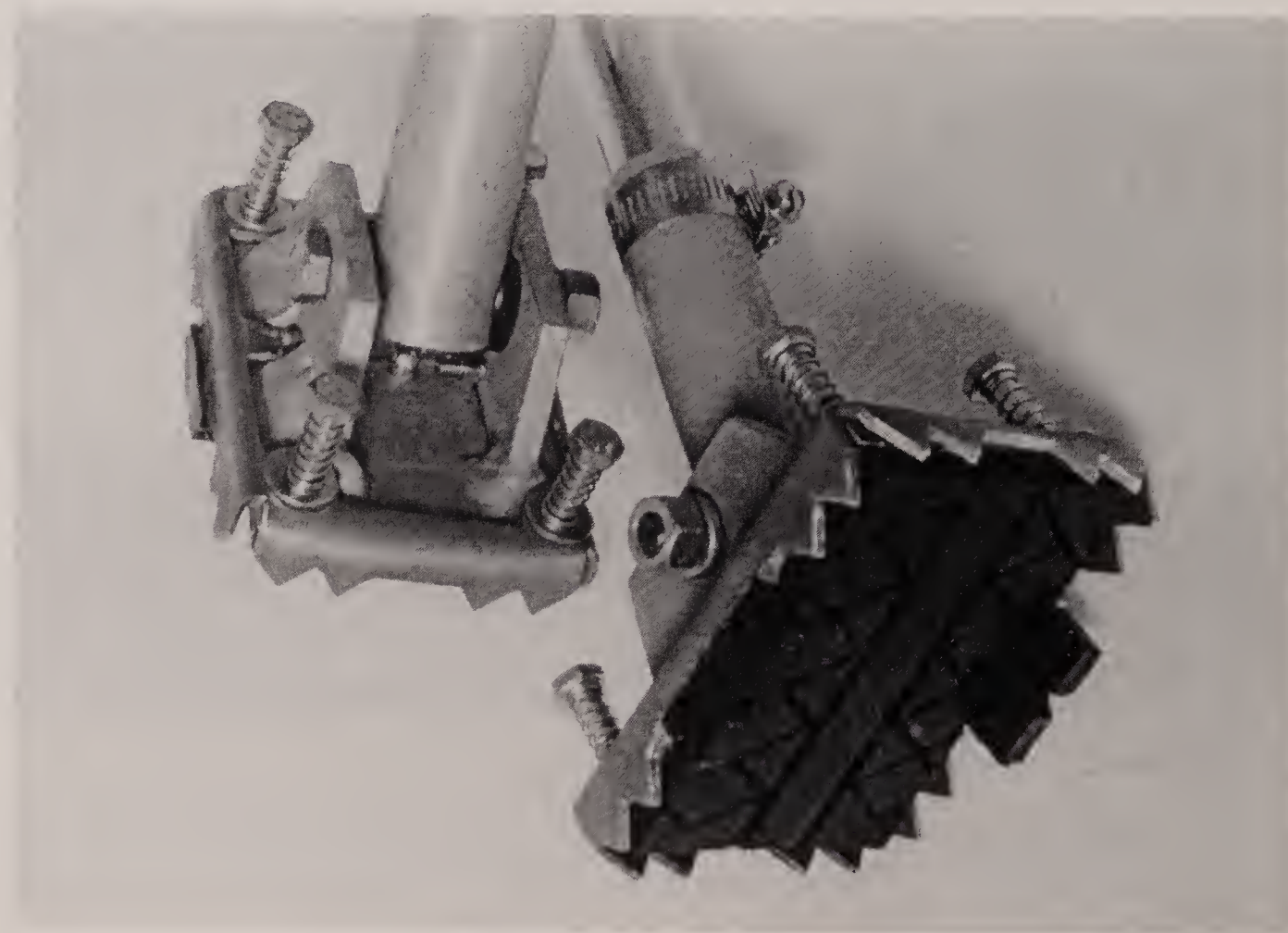


Figure 7.42 Anti-Slip Tread With Engaging Cleat

TECHNICAL DESCRIPTION

The primary component to this design is a base plate that supports both the cleat and attachment tube. The spring-loaded cleat travels on four bolts that are mounted into the base plate. This allows for smooth, even vertical movement of the cleat when being engaged or disengaged. The cleat is locked into the engaged or disengaged position by two ball plungers. The ball plungers are connected to a cable that is controlled via bicycle brake handles attached to the walking device.

The attachment tube is designed to rotate 120 degrees about the pivot joint hole and approximately 10 degrees laterally about the center of the base plate. This enabled the anti-slip device to adjust for uneven terrain by implementing dual axes of rotation. The attachment tube is also designed to be compatible with a variety of assistive walking devices.

The anti-slip tread with engaging cleat offers many advantages over current traction enhancements for assistive walking devices.

- Increased traction. The mechanism allows for major improvement in outdoor traction with increased floor contact in indoor areas.
- Dual axis of rotation. Contact surface with ground is maintained at all times for any walking motion.
- User friendly. Simple control requiring little effort to manipulate.
- Ergonomic. The addition of components alters the basic design of existing walking devices very little.
- Adaptability. A variety of devices can accommodate the mechanism.

PROCEDURE FOR MECHANISM USE:

Engaging cleat

- Pull lever, cleat travels to lower position.
- Release lever, plungers lock cleat into place.

Disengaging cleat

- Pull lever, retracting plungers.



Figure 7.43. Anti-Slip Tread With Engaging Cleat Mounted On Crutches.

- Press assembly against floor, raising cleat to upper position.
- Release lever, plungers lock cleat in upper position.

Testing procedures yielded favorable results. In comparison to conventional assistive walking devices, the most marked improvement with the cleat engaged is on ice in wintry conditions. With the cleat raised, the rubber pad provides excellent traction on all indoor surfaces, wet or dry. The tread pattern employed channels water away from underneath the unit, maximizing contact with floor surfaces at all time. The mechanism is also stable, durable, and light.

The cost of parts/materials was about \$100.

Ergonomic Ratchet Propulsion Device to Ease Stress on Wrists while Using Wheelchairs

Student Designers: Dong Won Kim, Kim Ming Chow, Sun Hum Choi and Jung Soe

*Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

The common commercially-available wheelchair design is not ergonomically optimal. Round handlebars attached to the wheels are particularly problematic. They force the user to use hand movements that might injure the wrists. The wrists must flex in such a way that they are strained. Skin can be damaged from rubbing against the handlebars. Also, the user hunches forward to propel the wheelchair, an impossibility for many people. These repetitive movements are especially difficult for elderly or weak users.

The racket propulsion device solves these problems by offering an alternative to the round handlebars, namely, levers to drive the wheels.

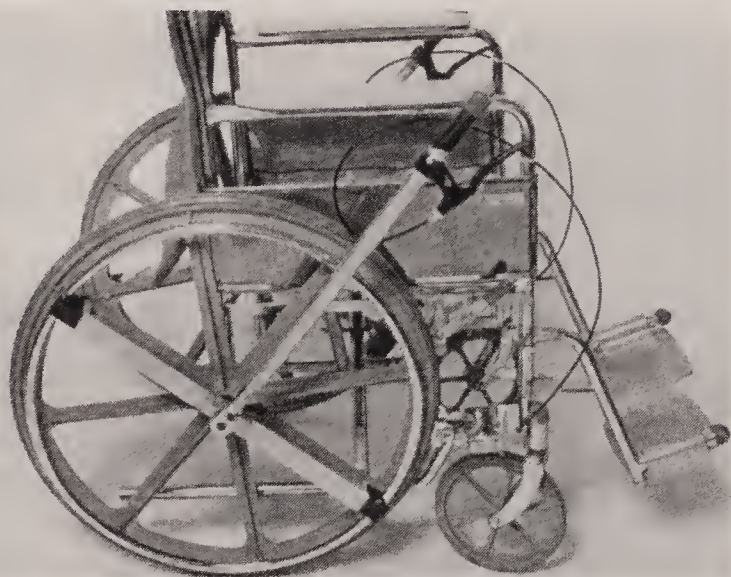


Figure 7.44. Close-Up Of Components Attached.

SUMMARY OF IMPACT

In order to allow the greatest number of people to use this device, it is designed to be: 1) simple, thus inexpensive; 2) easily attachable and detachable without tools; 3) collapsible; 4) maneuverable; and 5) adjustable (to fit a range of wheelchair sizes and styles). Additionally, it requires no permanent alteration to the wheelchair, thus preserving any

warranty. The arm levers use a pair of Sears Craftsman ratchets and bicycle brake levers.

It is hoped that this device will add comfort and convenience to the riding experience of its users.

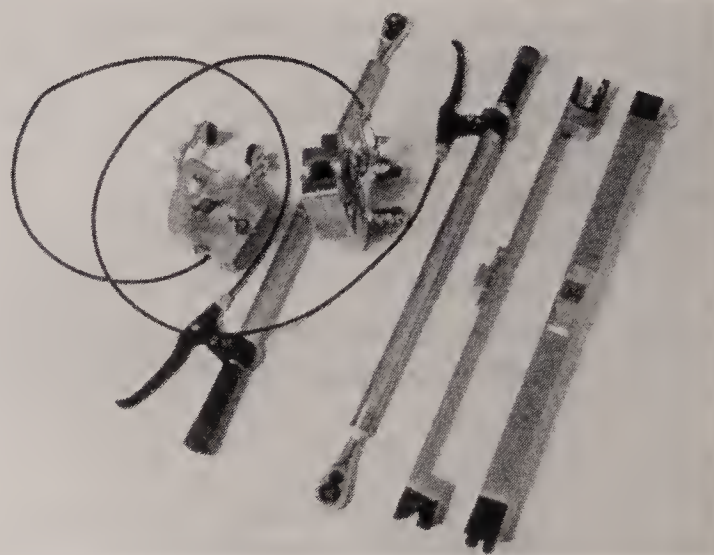


Figure 7.45. Dismounted Components Displayed.

TECHNICAL DESCRIPTION

The main idea of this propulsion device is that the user turns the wheels the way he or she would turn a nut with a ratchet. That is, in forward drive, the ratchets exert a torque on the wheels on the forward stroke, and none on the backward stroke.

The user pushes and pulls the arm levers, which pivot around the hubs of the crossbars. The crossbars rotate the wheels. At the hub end of each arm lever is a ratchet, which is reversible with a switch. At the arm lever's other end is a brake lever. The brake lever, via a cable, operates the brake mounted on the wheelchair frame.

The two crossbars are constructed of aluminum plates with clamps welded to the ends. The clamps go behind the wheels' round handlebars and are locked into place with pins. One clamp on each crossbar to

maneuver into place over a wheel. The ends are also plastic-coated to avoid marring the wheelchair.

The hub is an aluminum block machined to receive a ratchet. A hub is welded to the center of each crossbar.

Each brake is bolted onto two aluminum blocks, which are mounted onto the wheelchair frame. Two hand-operated wing nuts hold the two blocks

together, sandwiching a rubber-padded bar between them.

The cost of parts/materials was about \$145.



Figure 7.46. Components Attached.

A Temperature Sensing Cup that Alerts the User of Extremely Hot or Cold Liquids

*Student Designer: Won Ki Park
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

This project addresses the needs of persons affected with reduced sensory perceptions of taste and temperature in the mouth. There are medical conditions in which persons lose the ability to sense varying temperatures of solid or liquid intake. Elderly individuals may be particularly vulnerable to this type of condition, as sensory acuity often declines with age. Young children may also be at risk for intake of dangerous temperatures. There is a need for a device that alerts the user to extremes in liquid temperature.

SUMMARY OF IMPACT

The temperature sensing cup entails a temperature sensing device integrated with a cup. The temperature sensing device was chosen primarily for its effectiveness in detecting extremely hot temperatures, which tend to be most harmful. Various kitchen utensils (e.g., a soup ladle) could also be modified to include the temperature sensing device.

TECHNICAL DESCRIPTION

The device uses a quick temperature sensing instrument. The speed of temperature detection is an important factor since most users will not wait long before consuming a hot cup of coffee or soup. A

digital thermometer that incorporated a thermistor was chosen. The thermistor uses a ceramic device in which resistance drops dramatically upon exposure to high temperatures, thereby permitting a current to complete a circuit that will alert the user of sudden temperature changes. Tests of the thermistor device (U.S. Patent 5,165,798) in hot liquids gave good results.

The thermistor can be connected to visual or audio devices that will readily alert the user. Visual warnings may include a liquid crystal display, colored lights (for the color blind), etc. The audible alarm may include a buzzer, digital voice warning, etc.

The digital thermometer device is attached to a flexible plastic holder, and the ensemble can be mounted onto the upper wall of a coffee cup.

The cost of parts and materials was about \$20.



Figure 7.47. Digital Thermometer Inside the Modified Case Mounted on a Coffee Mug.

Motorized Exercise Bicycle Designed to Redevelop the Range of Motion in the Legs after Injury

Student Designers: Pamela Lyons, Mark Graham, Erik Tomer and David Spink

Supervising Professor: Dr. Joseph C. Mollendorf

Mechanical and Aerospace Engineering Department

State University of New York at Buffalo,

Buffalo, NY 14260-4400

INTRODUCTION

This project is designed to aid in rehabilitating the knees and surrounding tissues after reconstructive surgery. Following surgery many patients experience difficulty using exercise equipment such as stationary exercise bicycles. Many patients experience pain as their muscles are exerted in pushing the pedals. The large circular motion of the pedals can also be damaging and painful following surgery. Patients often need to start with small easy movement of their limbs.

The present design consists of a normal exercise bicycle that has been fitted with a motor to provide assistance in moving the pedals. The design also allows for different ranges of motion in the pedal stroke by providing adjustable crank arms for the pedals.

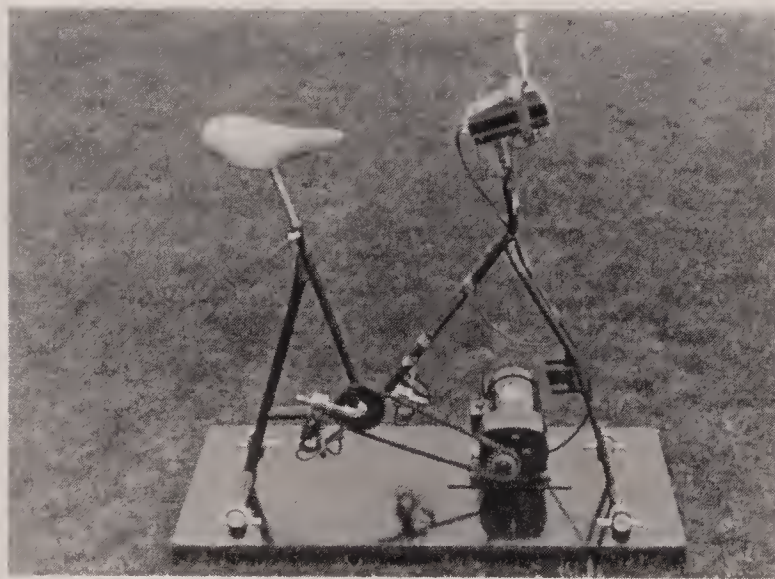


Figure 7.48. Motorized Exercise Bicycle.

SUMMARY OF IMPACT

It is anticipated that this device will speed up the patient's recovery as well as make it less painful. This design is also intended to make the rehabilitation process safer. Patients will be able to use the bike immediately following surgery instead of waiting until their muscles are strong enough to use a normal



Figure 7.49. Permanent Magnet Gear Motor.

bicycle. In addition, by using the crank arms, patients will be able to work their muscles at several ranges of motion. This will enable patients to use the bicycle at various stages of rehabilitation.

TECHNICAL DESCRIPTION

An existing exercise bike was modified to provide assistance during the entire pedal stroke. A motor was used to move the pedals, a DC controller to control the speed of the pedals, and adjustable crank arms to vary the range of motion at which the pedals rotate.

A 0.75 horsepower 90-volt permanent magnet DC gear motor with a parallel shaft was used. A torque limiter was attached, as a safety precaution, to the shaft of the motor. It will disengage if the patient's legs get caught or go in the opposite direction. The torque limiter sprocket was linked by a chain to a sprocket that controls the pedal movement.

The motor is bolted to a 1 inch board to provide support. The motor will supply .75 horsepower with a maximum speed of 40 rpms and torque of 705 in-pounds. This is more than enough torque for a

patient from 100-300 pounds. The motor is wired into a DC controller that enables the patient to control the speed at which the pedals rotate. This DC controller can also be set to control the deceleration, acceleration, maximum current and maximum speeds of the motor.

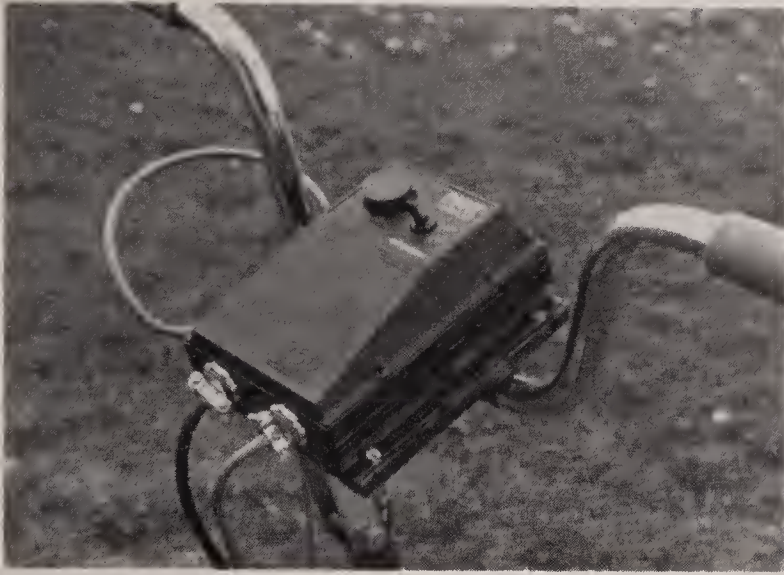


Figure 7.50. DC Controller.

This controller is mounted in between the handlebars so it is accessible to the patient, see Figure 7.50.

The original crank arms were cut off and new crank arms were welded on. To increase the strength of the weld, a dowel pin was inserted between the crank arm and the shaft. The adjustable crank arms have eight holes in them. The pedals can be removed and a pin can be set for smaller or larger ranges of motion (see Figure 7.51).

ACKNOWLEDGEMENTS

Willie Willerth provided assistance in choosing the proper motor and controller. Kenneth Peebles and Roger Teagarden provided assistance in the machining and welding of the crank arms.

The cost of the parts/materials was about \$900.

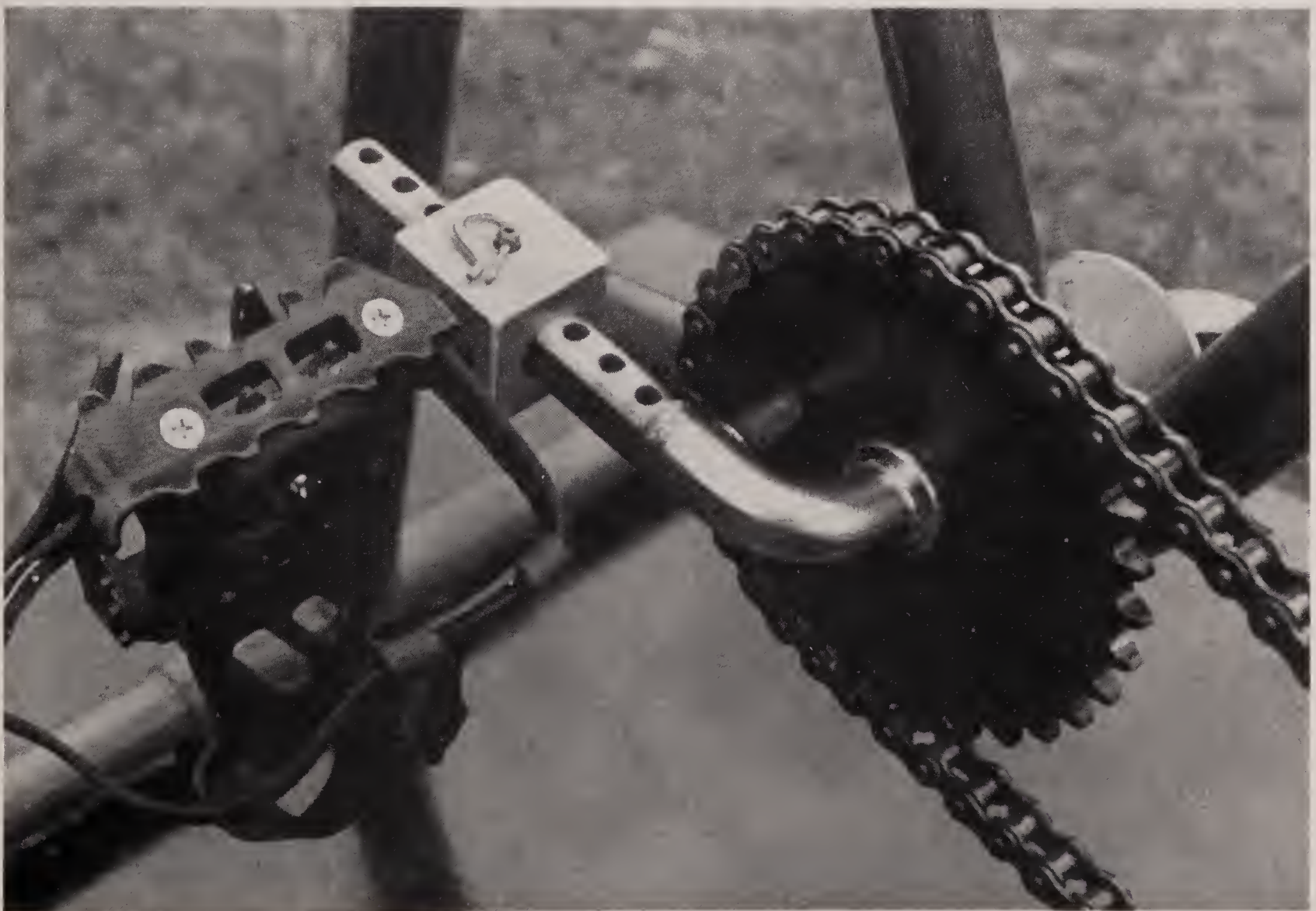


Figure 7.51. Adjustable Crank Arms.

The Countertop Jar Opening Device for People who Do Not Possess the Strength to Open Common Jars

*Student Designers: Neil T. Gillott, Glenn D. Mohr
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo,
Buffalo, NY 14260-4400*

INTRODUCTION

The motion of squeezing and twisting is problematic for people with arthritis, and for people with a lack of hand strength or motor control. One task that requires this squeezing and twisting motion is the opening of common household jars.

This device is designed to open a wide range of jars and bottle types and sizes, eliminating the twisting and squeezing movement. The lower mechanism secures the jar so that it will not spin while the jar is being opened. The upper mechanism is used to grab the lid and twist it. The upper mechanism is controlled through a simple toggle switch, and the lower mechanism is controlled through a push button. Neither control mechanism requires significant strength or advanced motor skills for operation.

SUMMARY OF IMPACT

When this jar opener is used as an assistive device in the home, the need for others' help will be eliminated. Large amounts of foods today are packaged in jars. Hopefully, having access to these foods at all times, without the help of others, will increase the quality of life of challenged people. Another benefit of this device is that its use is not limited to the elderly or disabled. Many people experience problems opening very tightly sealed jars. This device can help all people in these situations.

TECHNICAL DESCRIPTION

The range of the opener was made for jars as small as baby food containers and as large as a two-liter soda bottle. The height differential is made possible through a linear bearing that may be adjusted to fit any height jar.

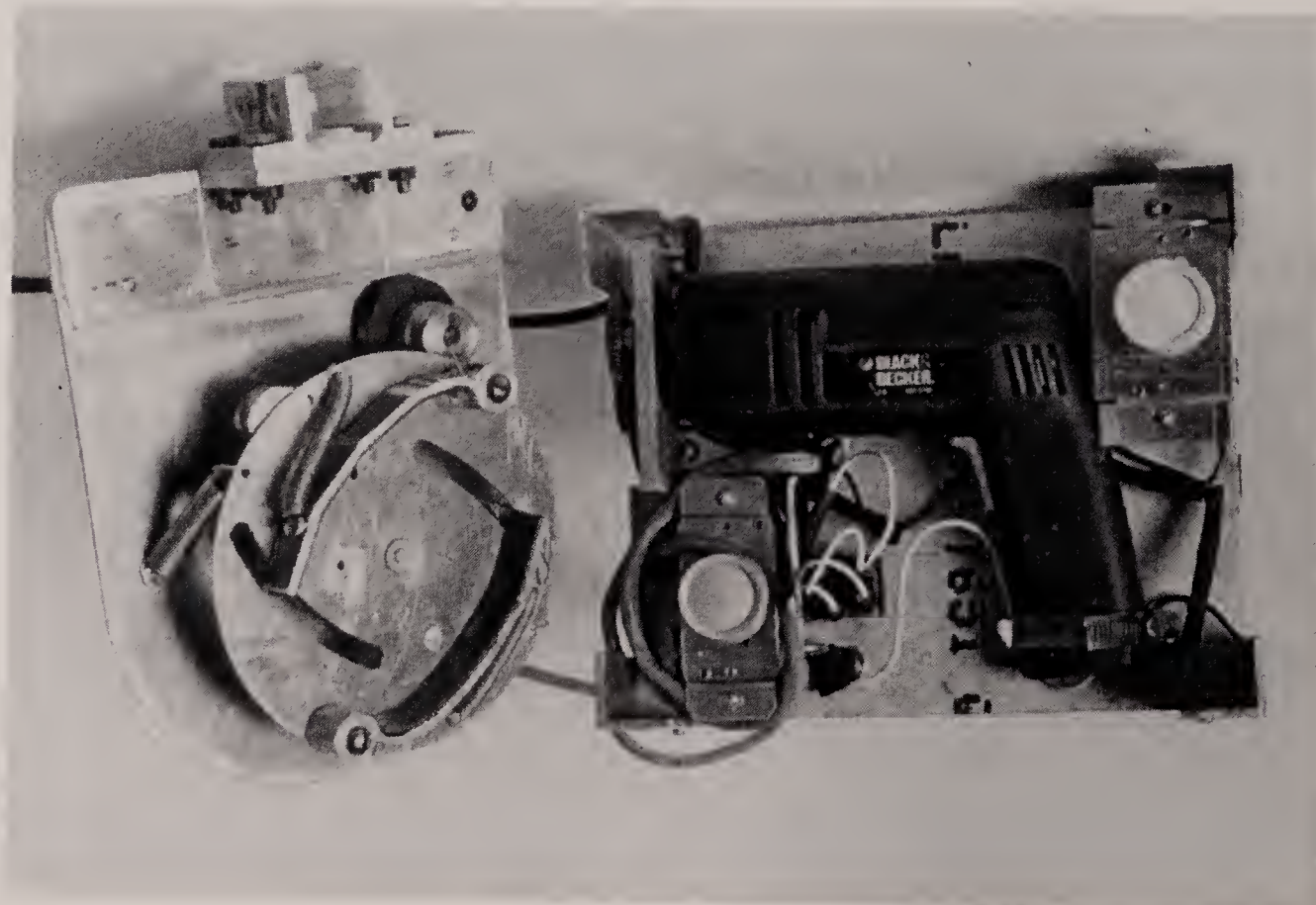


Figure 7.52. Upper and Lower Mechanisms.

The lower unit, which is used as the jar locking mechanism, is a center closing vise. This type of vise was used because the center of the jar has to remain in a constant position regardless of the diameter of the jar. This is important for the function of the upper unit. For the prototype, aluminum was the material of choice. The unit has rubber padded V-type jaws to help eliminate slippage. The vise is center closing due to left and right handed threaded rods welded together at the center. Guide rods were added to give the vise jaws added strength and increased stability. The unit is powered through a mechanically reversible three-amp hand drill motor. A hand drill was used because of its ease of adaptability, and because it was substantially cheaper than a bulk motor. The motor is operated by the push button switch. A jar is placed in the vise and the button is pressed. The motor rotates the threaded rod and the vise is closed on the jar. Pressure on the jar is limited by the press fitted gear attached to the main shaft. The gear spins freely after a certain amount of force is applied. This force is suitable enough to hold the jar without spinning or crushing it.

The upper mechanism is designed to grab the lid and rotate it, releasing the lid from the jar. The design is similar to a drum brake on a car. This grabbing mechanism rotates, creating the twisting motion necessary to remove the lid. The arms are designed to work for any jar style. The arms have a height of $3/4$ inch. This height allows the greatest range of jars to be opened. The arms are attached to the drive motor by a high strength fishing wire. The resistance springs do not allow the mechanism to rotate until the arms are right on the jar lid. When the arms are tight on the lid, the force of the resistance springs is overcome, thus allowing the mechanism to turn. When the mechanism turns, the jar lid is removed. The motor is then reversed by switching the toggle switch in the opposite direction. When the motor starts to back off, it releases the pressure on the lid and returns to the beginning position.

The circuitry involved in the jar opener is different for the two motors. The drill used for the upper mechanism has an electrically reversed motor. A momentary double through double pole switch was used. This switch is used to replace the trigger switch

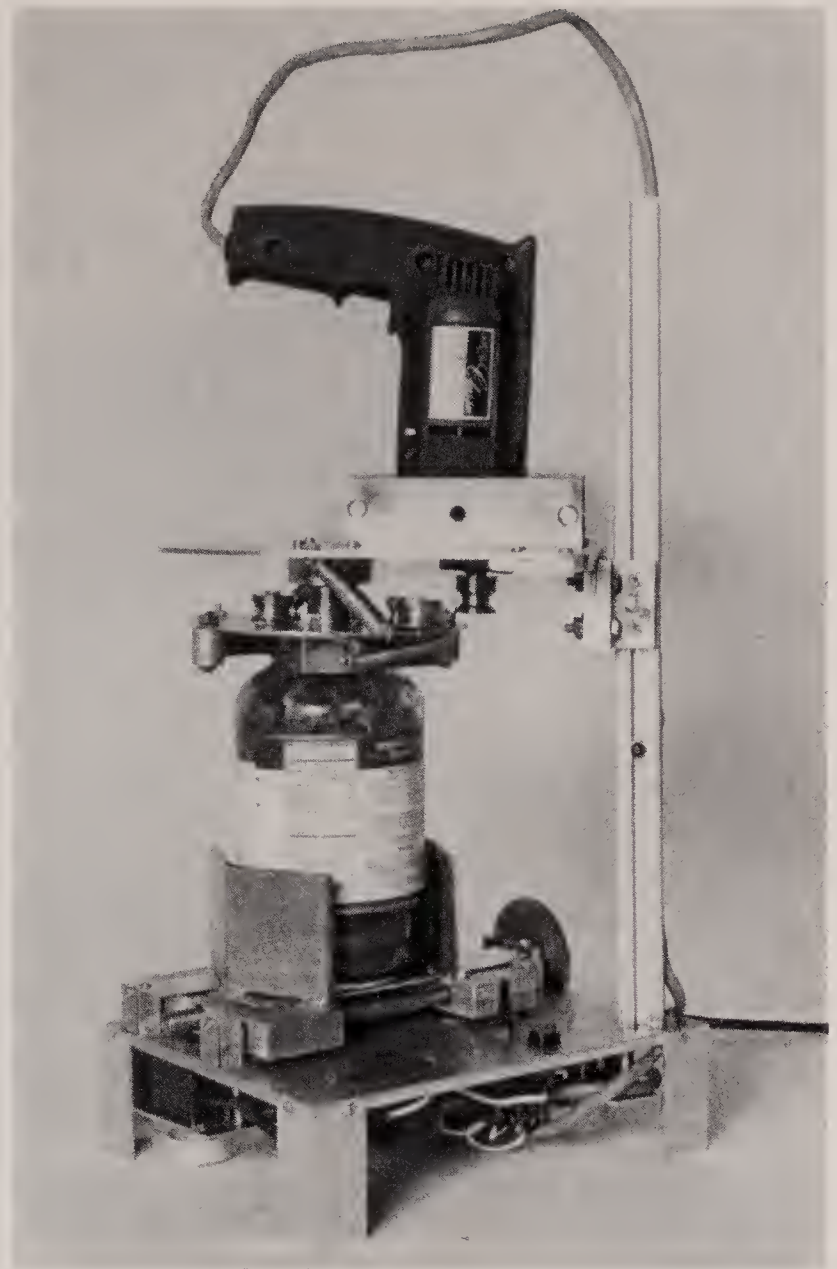


Figure 7.53. Jar Opener With Jar.

that comes with the drill. Reversing the action of the motor is as simple as switching the toggle switch in the other direction. A dimmer switch is used to control the current and is used as a speed control for the mechanism. The drill used for the vise mechanism is a mechanically reversible motor. It is controlled by a momentary single pole single through switch. To reverse the motor, a switch on the drill housing must be used. A dimmer switch was also incorporated into the circuit for use as speed control.

The cost of the parts/materials was about \$226.



CHAPTER 8

TEXAS A&M UNIVERSITY

College of Engineering
Bioengineering Program
College Station, TX 77843

Principal Investigator:

William A. Hyman (409) 845-5532
w-hyman@tamu.edu

A Device For Teaching Manual Wheelchair Propulsion

Designers: John Lemons and Allister Chang

Client Coordinator: Greta Cherry, United Cerebral Palsy of Greater Houston

Supervising Professor: W.A. Hyman

Bioengineering Program

Texas A&M University

College Station, TX 77843

INTRODUCTION

A device has been designed to facilitate the training of young children in the use of a wheelchair. When the wheels of this device are turned, a remote controlled vehicle will respond to the movement of the wheels in accordance with the way that a wheelchair would respond. Turning both wheels of the chair forward causes the remote controlled vehicle to move forward. Similarly, turning both wheels backward causes the vehicle to move backward. Moving only the right wheel moves the vehicle left and either forward or backward. Rotating only the left wheel moves the vehicle to the right and forward or backward.

SUMMARY OF IMPACT

In conjunction with other forms of training, the wheelchair trainer helps to teach the concept of moving a wheelchair in a particular direction by moving its wheels. The device was designed for preschool-age developmentally delayed children who have physical limitations that require them to become wheelchair users. The chair is stationary, allowing the therapist to work closely with the user.

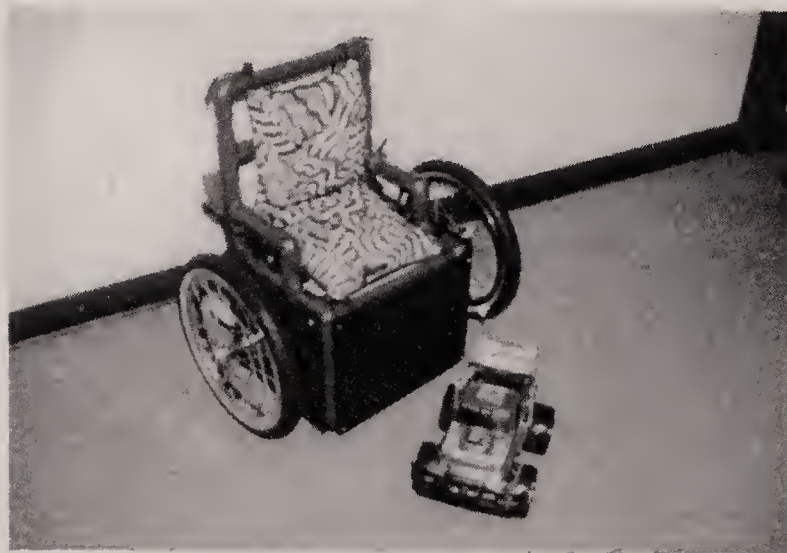


Figure 7.1. Wheelchair Trainer II.

Another potential population that may benefit from this design is children that have strong dominance for one hand. Since the device requires the use of both hands to make a toy or other output device operate, its use by this group will encourage bilateral development. The training device will remain in the ther-

Table 8.1. Remote Controlled Vehicle Response to Wheelchair Trainer Movement

Wheelchair Action	Truck Response
Both wheels turned forward	Moves forward
Both wheels turned backwards	Moves backward
Right wheel turned forward	Moves forward and to the left
Right wheel turned backwards	Moves backward and to the left
Left wheel turned forward	Moves forward and to the right
Left wheel turned backwards	Moves backward and to the right
Right wheel turned forward and Left wheel turned backwards	Steering wheels turn left but the truck does not move
Left wheel turned forward and Right wheel turned backwards	Steering wheels turn right but the truck does not move

apy center for use by a number of children undergoing similar therapy programs.

TECHNICAL DESCRIPTION

The frame of the wheelchair trainer is constructed of PVC pipes. A seat cushion is provided for comfort. Nylon straps connected to the frame of the trainer support the cushion. The wheel axles are mounted through the wood framing and are independent of one another.

An optical encoder (Hewlett-Packard HEDS 5500) is

mounted on the end of each axle. The encoders produce two pulsatile outputs (square waves) that vary according to the direction of each wheel rotated. When a wheel spins in a particular direction, one output will lead the other by a certain phase. For example, when the wheel is spinning forward, output A will lead output B; when the wheels are spinning backward, output A will lag behind output B.

The wheelchair trainer circuitry is implemented on a printed circuit board (PCB). The advantages achieved by using a PCB include easier replacement of inte-

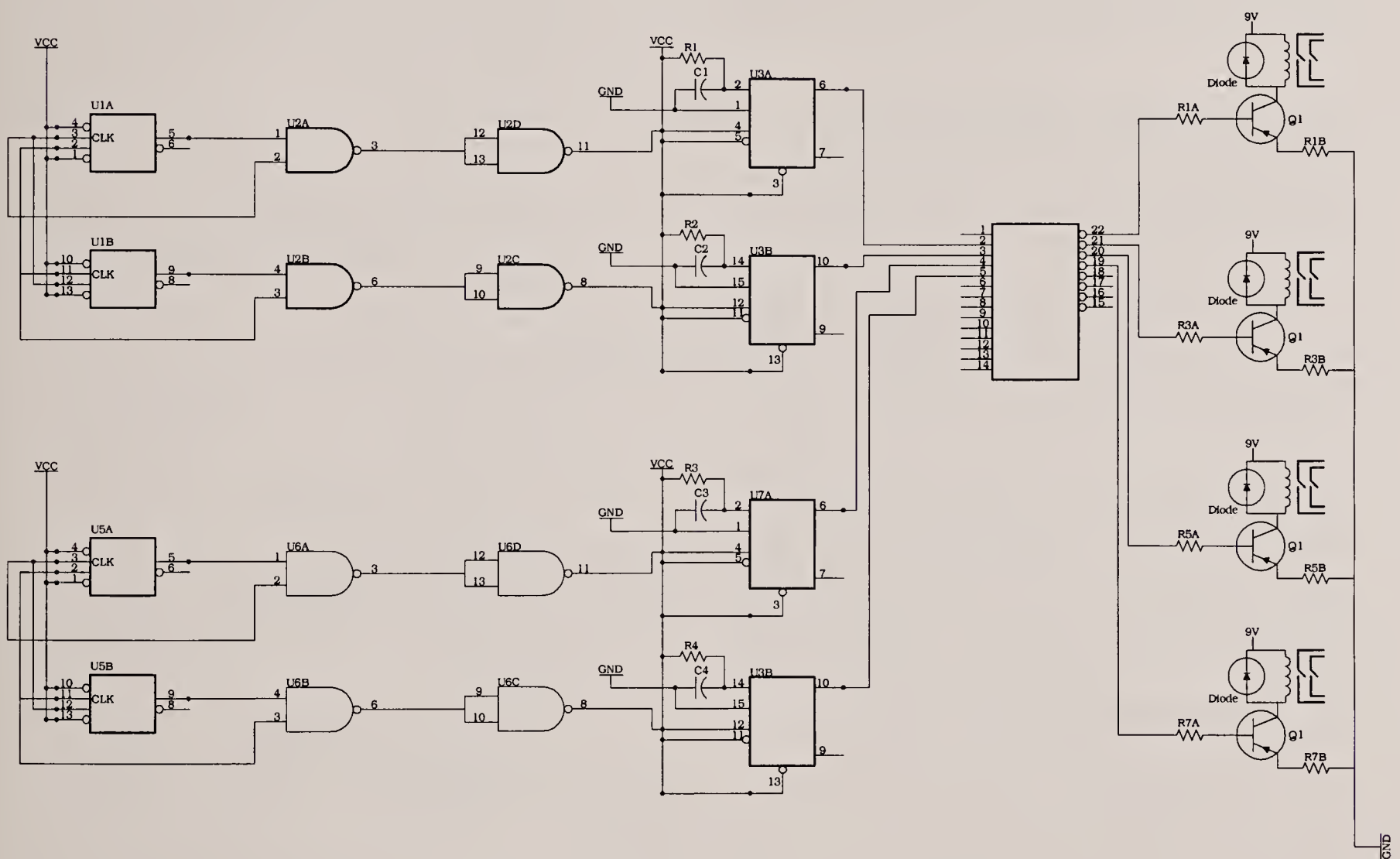


Figure 7.2. Wheelchair Trainer Circuit

grated chips, better performance consistency, and a cleaner layout.

The output of the optical encoders is received by D flip-flops (74LS74). The output of the flip-flops is then input into a series of NAND (74LS00) gates in conjunction with the encoder outputs. The NAND gates output is input into dual precision monostable multivibrator integrated circuits (74HC4538). The circuit contains two 74HC4538 chips, and each chip contains two monostable multivibrators. One output on each chip outputs high when its corresponding wheel rotates forward, and the other output is high when its corresponding wheel is rotated backward. These four outputs are connected to an AMD PAL (PALCE20V8). A PAL was used instead of traditional logic because individual gates would have occupied more space on the PCB than the PAL would. Furthermore, using a PAL allows one to modify the behavior of the wheelchair trainer more easily by simply reprogramming the chip.

The PAL performs the logic required to convert the output of the monostable vibrators to the remote control. The outputs of the PAL are input into the base of a BJT NPN (2N2222) transistor. The transistor is used as a switch; when its base is high it is switched on, allowing current to flow from the collector to the emitter. When current flows through the transistor, it triggers the reed relay to the closed position. This connects the appropriate pads of the remote transmitter and causes the car to respond accordingly.

The circuit is powered by a nine-volt DC input provided by a store-bought transformer, which runs on conventional 120 V AC. Because TTL logic and the optical encoders require five-volt power, a voltage regulator (LM 7805) was used to lower the voltage power from nine to five volts.

The total project cost was \$475.

PARTS LIST

Hewlett Packard HEDS 5500 Encoders (2)
 Terminal Strip Jacks (6)
 Terminal Strip Plugs (6)
 Reed Relays (4)
 24 Pin DIP Sockets (1)
 Encoder Plugs (2)
 Encoder Plug Connector Pins (10)
 Printed Circuit Board
 10"x8"x3" Aluminum Chassis
 Box Lid
 4.9 μ F Electrolytic Capacitors (4)
 Silicon Diodes (4)
 N2222 Transistors (4)
 Resistors (8)
 Spacers (4)
 Heat Sink
 AMD PALCE20V8H
 Remote Controlled Vehicle
 NiCad Rechargeable Battery Pack
 Battery Charger
 AC/DC Converter
 Rocker Switch
 Power Socket
 25' Roll of 24 Gauge Wire (4)
 1/2"x2'x8' Plywood Board
 1/2"x2'x4' Pine Board
 Epoxy
 5/16 Hex Nuts (4)
 1/4 Zinc Washers (4)
 Electrical Tape
 Corner Brace
 1/2"x3' Pipe
 3/8" Fender Washers (4)
 3/8" Threaded Steel Rod (2)
 1"x6' PVC Pipe (3)
 1" PVC Pipe Connectors (14)
 1/2"x1' PVC Pipe (2)
 Spray Paint
 Pillows (2)
 9' 1/2" Nylon Strapping
 7.5' 1/4" Nylon Strapping
 Pillow Blocks (4)

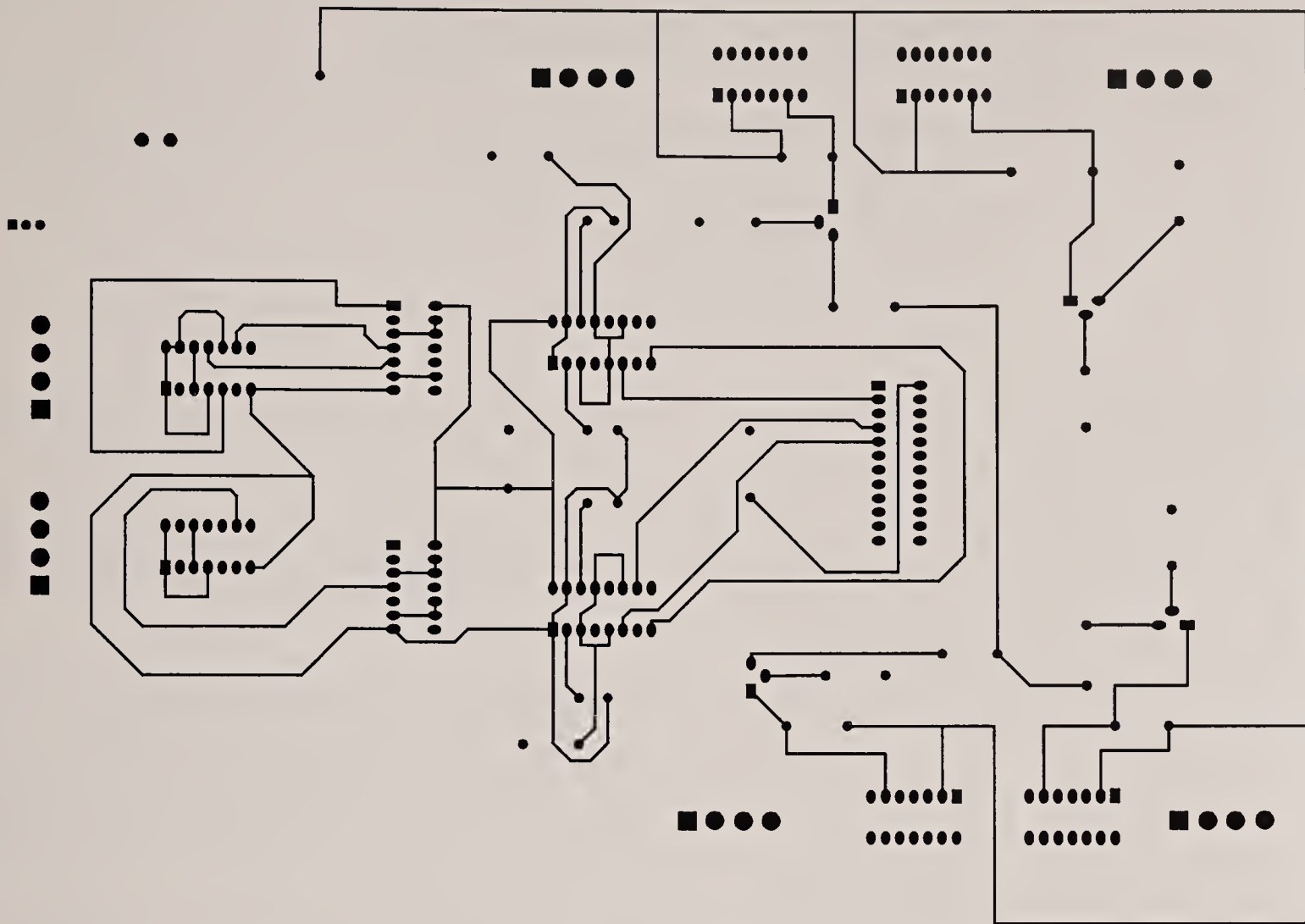


Figure 7.3. PC Board Configuration.

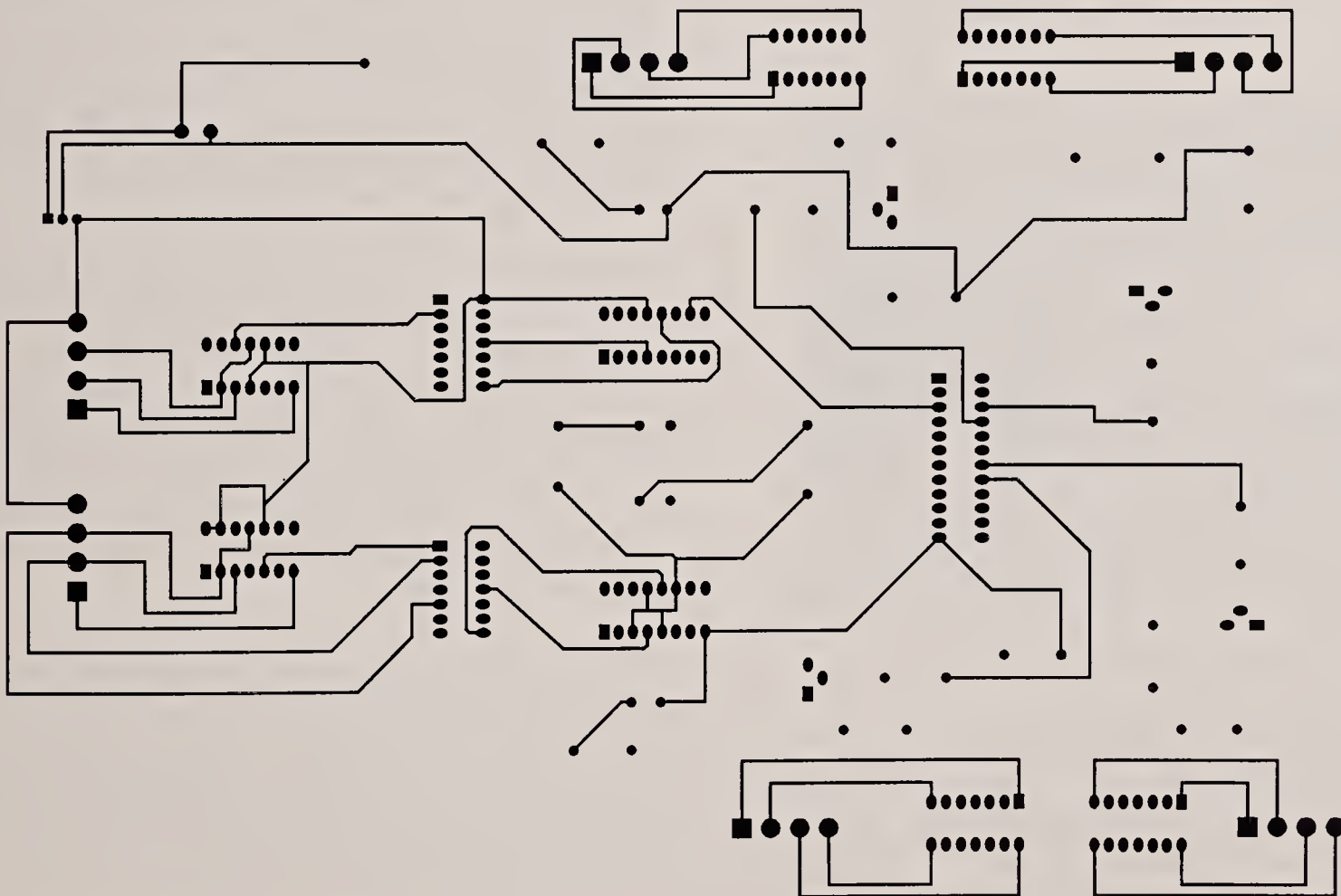


Figure 7.4. PC Board Configuration.

Aggie Inclinometer II

Designers: Wendy Blair, Coreen Vallance

Client: EQUEST Hippotherapy, Dallas

Supervising Professor: W.A. Hyman

Bioengineering Program

Texas A&M University

College Station, TX 77843

INTRODUCTION

Patients who suffer from motor disorders such as cerebral palsy often undergo hippotherapy, a treatment that involves horseback riding. Young patients are securely positioned on horseback, and a therapist leads the horse. It is often difficult for the patient to hold his or her head in an upright position while riding; the activity thus stimulates muscular and cognitive exercise that may enable the patient to more easily hold his or her head upright during normal daily activity.

An inclinometer was designed to monitor progress in maintaining an upright position during therapeutic horseback riding. Placed upon the patient's head, it measures the angle at which the patient's head deviates from the horizontal.

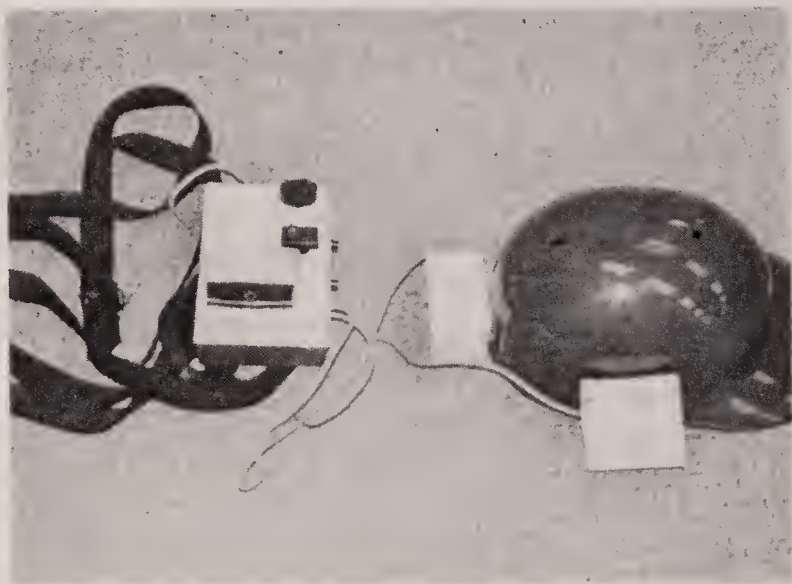


Figure 7.5. Aggie Inclinometer II.

SUMMARY OF IMPACT

It is often difficult for a therapist to determine rates of patient improvement during hippotherapy. Ideally, the patient's head will gradually stay in a more upright position and will experience a lesser degree of bouncing as therapy progresses. By providing a measurement of the angle that the patient's head

bounces, the inclinometer data helps the therapist to accurately judge the patient's rate of improvement. An earlier inclinometer design measured only the forward or backward head bouncing for the patient, while the inclinometer II design measures forward, backward, and side-to-side motion to provide a more complete data set for the therapist.

TECHNICAL DESCRIPTION

Operation of the inclinometer II is based on a pendulum mechanism. A fishing weight is attached to a 100k Ω potentiometer that is located on the headgear. The fishing weight circuit located on the right side of the headgear measures forward and backward motion, while that located on the back of the headgear measures side to side motion. When the patient's head moves, the weight remains perpendicular to the ground as a result of gravity. The resistance of the potentiometer, which is originally centered at 50k Ω , will change with respect to the direction of motion. This change in resistance will change the output voltage that is read on the attached voltmeter.

In order to allow easy calibration, the design uses a whetstone bridge with two potentiometers. The top potentiometer is the fishing weight circuit located in the headgear. The bottom potentiometer is a dial centered at 50k Ω that the therapist must adjust until the voltmeter reads 2.5 volts. Since the amplified output of the whetstone bridge is calibrated such that it is balanced at 2.5 volts, the output voltage will remain in the 0 to 5-volt range.

The voltage across the dial potentiometer is inverted and then summed with the voltage across the second 10k Ω resistor. The output voltage of the summer is 0.05 volts. The sum is then amplified with a gain of 50. Thus, the output voltage when the circuit is calibrated is designed to be 2.5 volts.

The op-amps utilized are eight-pin 741 dips. The fourteen op-amps are responsible for inverting, buff-

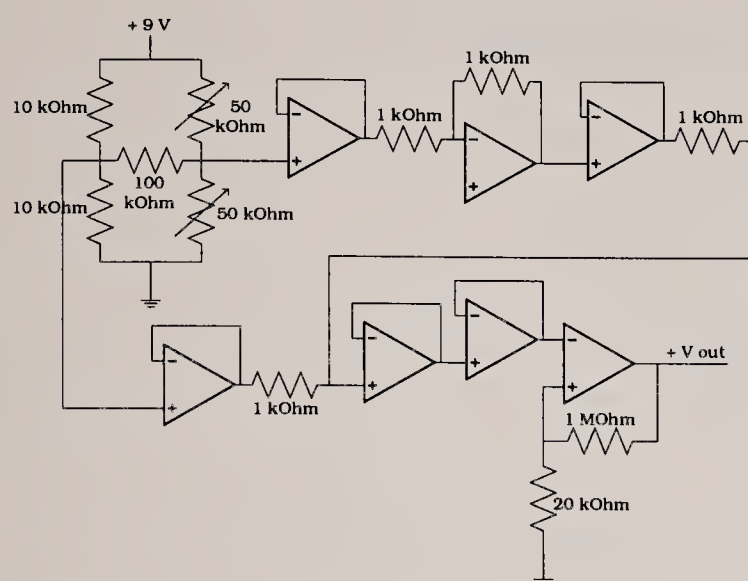


Figure 7.6. Wheatstone Bridge Schematic.

ering, summing, and amplifying the output signal from both headgear circuits. Two 9-volt batteries are used to power the op-amps. There are two switches in the circuit: an on-off switch for both batteries, and a DPDT switch that alternates the headgear output monitored on the voltmeter.

Each fishing weight circuit is housed in a casing mounted on the headgear. The majority of the main circuit, including op-amps, dials, switches, and the voltmeter, is housed in one casing which is worn like a backpack. In addition, the inclinometer II headgear consists of a plastic baseball-batting helmet with an adjustable chinstrap. The flat surfaces on the sides and back of the helmet ensure that the fishing weights will remain perpendicular to the ground. The two casings are attached to the helmet with Velcro and are marked with the proper placement directions. The helmet is easy to put on and remove.

The therapist must switch between front / back and side to side orientations in order to read both meas-

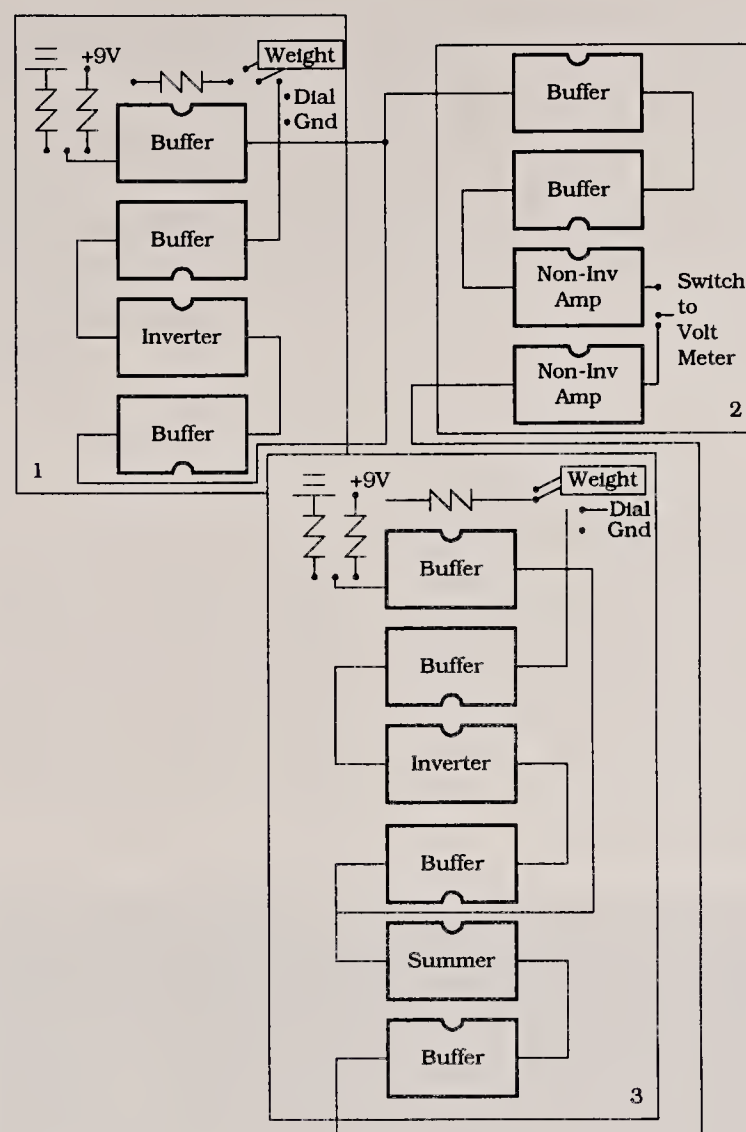


Figure 7.7. Circuit Board Layouts.

urements on the voltmeter. Changes in the output voltage after both dials have been calibrated at 2.5V illustrate deviations between the patient's head position (either front to back or side to side) and the horizontal.

Musical Balance Beam

Designers: James Pearce, Bala Sundararajan

Client Coordinator: Greta Cherry

United Cerebral Palsy of Greater Houston

Supervising Professor: W.A. Hyman

Bioengineering Program

Texas A&M University

College Station, TX 77843

INTRODUCTION

The musical balance beam is used in physical therapy to help teach children how to walk and control their balance while making the task fun and entertaining. It emits musical sounds for each assigned step taken along its length. When the child walks along the beam, he or she is rewarded by tunes from an attached music box.



Figure 7.8. Musical Balance Beam.

SUMMARY OF IMPACT

Cerebral palsy is a condition characterized by paralysis, weakness, incoordination, or other motor problems. It is caused by pathology of the motor control centers of the brain. Children with this condition often become dependent on wheelchairs. Their walking and balance skills are greatly reduced through lack of use. This balance beam provides a fun means for children with physical handicaps to practice walking and balancing capabilities. Children who are capable of walking but have balancing difficulties can also utilize the beam. A trained adult should always help patients by guiding them along the path.

TECHNICAL DESCRIPTION

The beam was constructed out of wood. Foam padding was used for cushioning and support. The beam is six inches wide and eight feet long, with a height of only five inches to reduce the risk of injury from falling. The beam has ten assigned steps. Each step is a $3\frac{1}{4}$ -inch wooden square that activates a momentary pushbutton switch located directly under it. Each switch is connected to a sound card. Since each sound device consists of only a few sounds, two sound devices are necessary to complete different musical tunes for each of the ten steps of the beam. The beam does not have assigned step squares at the beginning or end to provide the child with a small practice area before the musical switches are encountered. The top of the beam is padded with foam.

A 4-inch by 6-inch by 8-foot wooden beam acts as the base. Ten holes were drilled in the beam to house the push buttons. In addition, wire paths were routed along either side of the beam, approximately 1 inch from each side, with smaller pathways drilled to connect these to the push button switches. A $\frac{1}{2}$ -inch by 6-inch by 8-foot strip of plywood was utilized for the top wooden piece. Ten $3\frac{1}{4}$ -inch squares were cut from this plank, using a jigsaw, to allow access to the underlying pushbutton switches. These squares were

later placed in their respective holes to serve as the steps of the beam. Ten corresponding 3¼-inch squares were cut from a 3/8-inch by 6-inch by 8-foot foam padding layer. This foam was glued to the plywood layer, allowing the underlying steps to be depressed and activated.

Each of the momentary pushbuttons is connected to a sound card. The pushbutton has two prongs; each prong is attached to a wire that runs along the drilled pathway to a sound device. A thin groove was drilled in the sound devices to allow the wires to run through the casing and to the sound card. At the sound card,

each wire is connected to only one side of the interlocking wire circuit. Therefore, when the button is depressed, the circuit is closed and a particular sound is emitted until the button is released. The sound devices were mounted in pairs on either side of the beam, with the speakers and batteries facing outward for audibility and accessibility. Total project cost was approximately \$60.

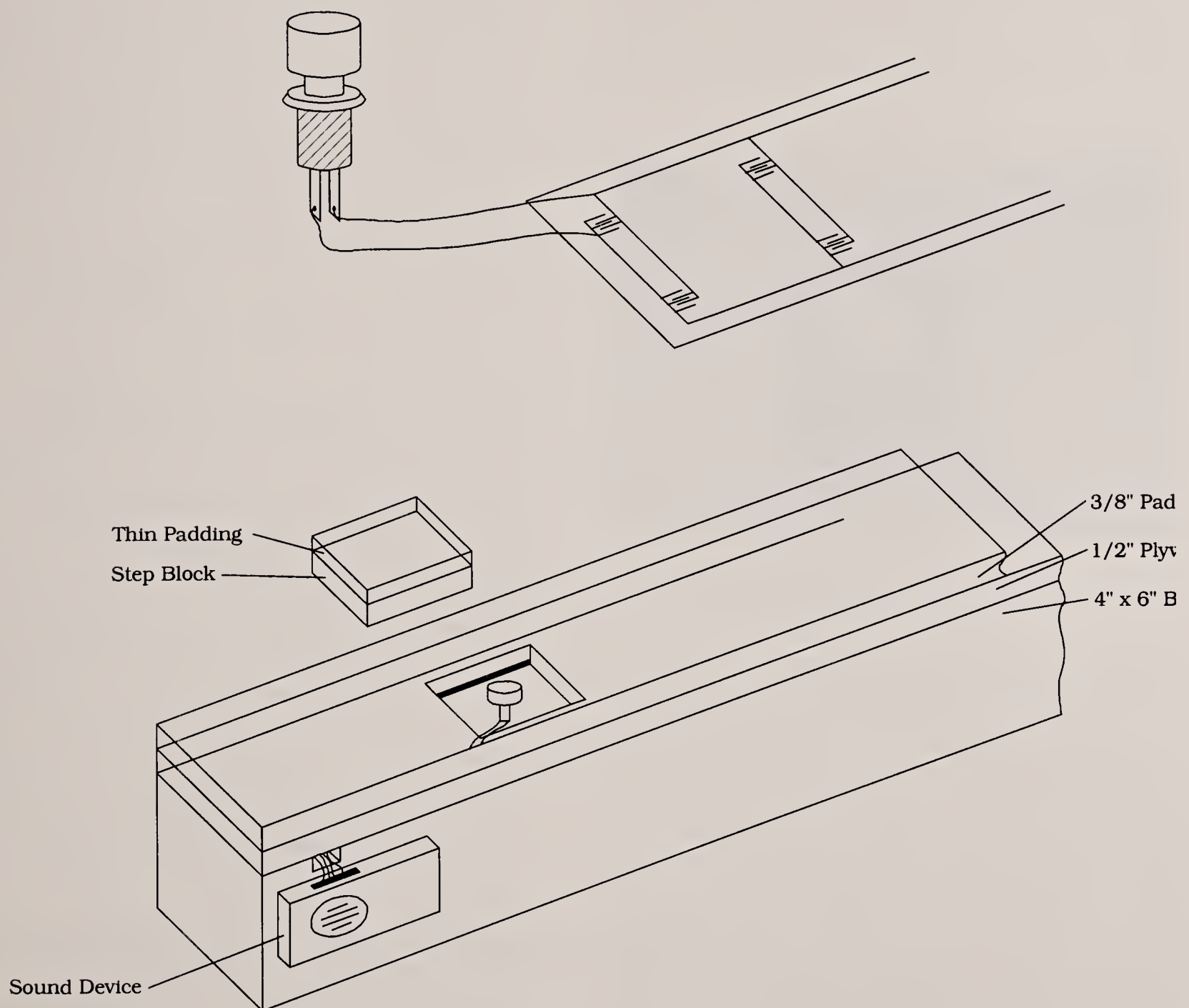


Figure 7.9. (Top) Push Button Connection to a Sound Card. (Bottom) Assembled Musical Balance Beam.

Motion Sensor Switch

Designer: Hoan Le

Client Coordinator: Greta Cherry

United Cerebral Palsy of Greater Houston

Supervising Professor: W.A. Hyman

Bioengineering Program

Texas A&M University

College Station, TX 77843

INTRODUCTION

A motion-sensing switch was built to enable children to operate a toy through play and bodily motion. This device emits a passive infrared beam in a path approximately five feet in diameter; any motion within that range will be detected, and the switch will be activated. When there is motion near the device's field of vision, it emits two pulses of activation. Each pulse lasts approximately one second.



Figure 7.10. The Motion Sensor Switch.

SUMMARY OF IMPACT

The learning and developmental processes of children, especially those who have physical disabilities, can be aided by the use of toys. Directed and purposeful play can allow a child to develop cognitively, physically, emotionally, and socially. Play is often conducted with a battery powered switch toy. The action of pushing a switch can be a hindrance, or can distract the child from play. Sometimes a physically challenged child cannot perform the simple function of pushing a switch. Thus, this motion sensor device can greatly aid the child in fully interacting with the toy without having to push any kind of switch. To

trigger the toy, the child must simply move around while playing with the toy in the diameter of the motion-sensing device. In addition, several motion detectors can be positioned around a room to activate a certain toy in a particular motion sensor's range. A child ideally learns to associate motion with the reinforcement of activating a toy. If several motion sensors are placed throughout a room with corresponding toys, a child may also develop memory skills by associating the toy's action with its location. Further, the child may benefit from physical exercise obtained by moving to trigger the toy. The child may also enjoy the pleasure and excitement of interaction with the toy because he or she knows that his or her movement can trigger the toy. Lastly, the child can interact with other children during play; children may, for example, take turns activating the toy.

TECHNICAL DESCRIPTION

The detector was built with a 6076-KT Passive Infrared (PIR) Detector kit. This kit utilizes an MPCC chip that controls the passive infrared detector. A sensitivity adjusted 500k Ω potentiometer was soldered from pin 2 to pin 7 on the MPCC chip. This adjusts the detector's sensitivity level, or the amount of motion that must occur before the device triggers the toy via the switch. The relay is then connected to its coil from the output of the detector kit, or the output port on the MPCC chip. As motion is detected, the output will close the circuit on the switch, and consequently switch the toy on for a one-second pulse. A nine-volt power plug with a battery disable or a nine-volt battery source is used to power the MPCC chip. A power switch is connected to the common ground to disconnect power to the MPCC chip. A plastic hood around the sensor dome is used to limit the range of the motion-sensing device to the desired five-foot diameter. The hood may be removed if a larger range is required.

The device will work best if it is placed about seven to ten feet above the highest motion (i.e., above the head of the tallest child). The best sensitivity is achieved when motion is across, rather than in line with, the device's path of projection; a potentiometer that allows sensitivity adjustments was added. When motion stops, the device turns off the switch with little delay. The device can be powered by a nine-volt battery or a nine-volt DC power supply. To save power, the device also contains an on-off switch. In addition, the device has an output port for a 1/8-inch conductor jack.

Additional information can be obtained by consulting an MPCC specification sheet.

Figure 7.12. Assembled Motion Detector.

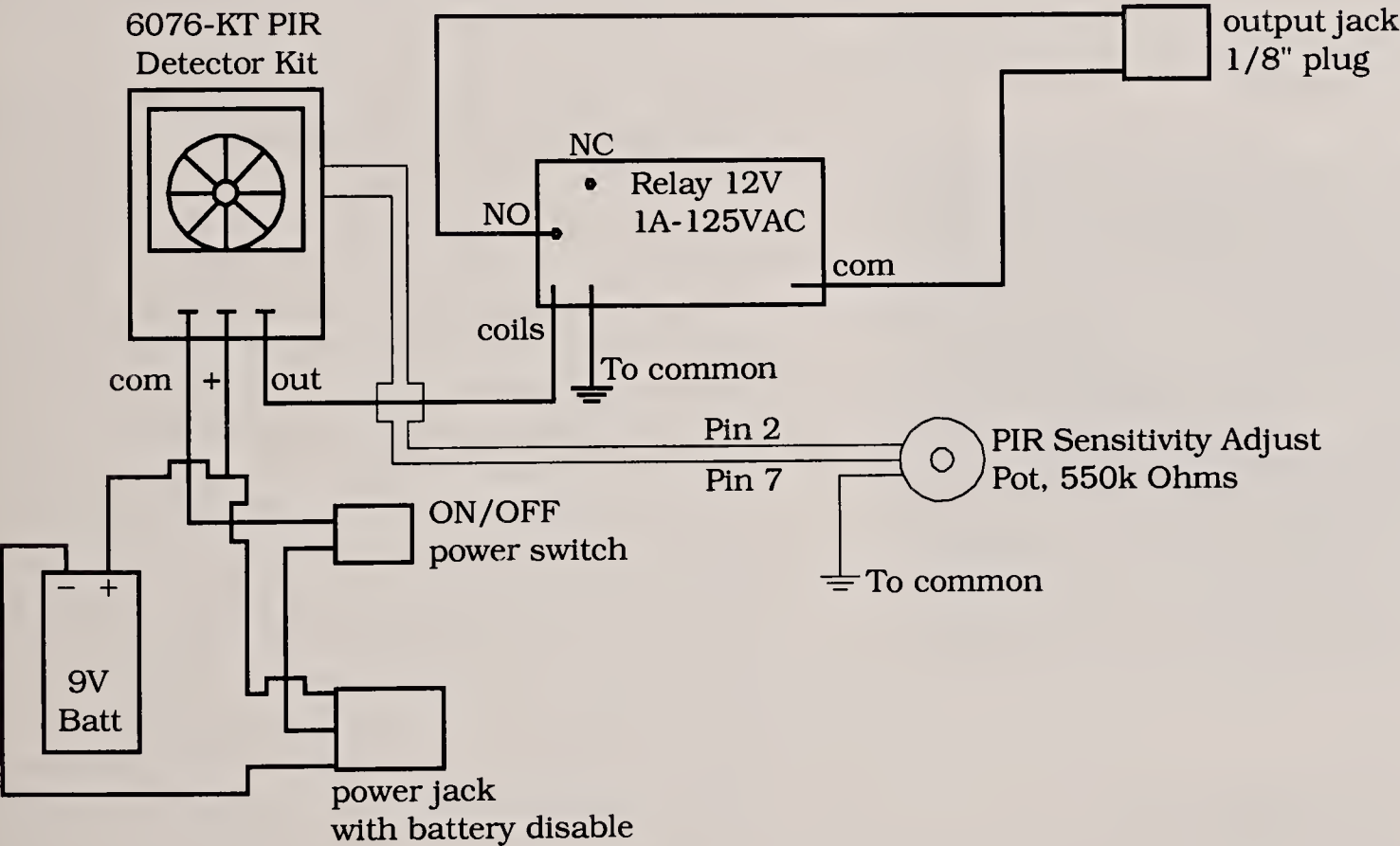
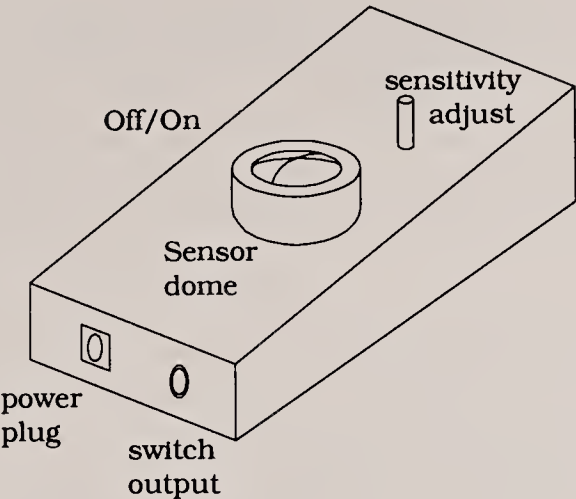


Figure 7.11. Hardware Assembly Drawing of the Motion Detecting Device.

Play Table For Children With Cerebral Palsy

*Designers: Lauren Green, Brad Putty
Client Coordinator: Simone Braquet
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Bioengineering Program
Texas A&M University
College Station, TX 77843*

INTRODUCTION

A play table was designed for one- to three-year-old children at the United Cerebral Palsy Foundation in Houston. The play table consists of three stacked play surfaces supported by adjustable legs. The top surface contains brightly colored, primary shaped indentations for the placement of wooden pieces of corresponding colors and shapes. Electrical circuitry beneath the top surface provides auditory and visual rewards when the wooden pieces are placed in their correct position. The middle surface is a layer of clear Plexiglas for use with markers or "messy" substances such as shaving cream. Beneath the Plexiglas, the bottom surface is attached to the legs of the table and contains an inset bin for the purpose of holding water. The legs of the table can be adjusted to provide table heights of 12, 15, or 18 inches.



Figure 7.13. Play Table.

SUMMARY OF IMPACT

Because young children with cerebral palsy may lack a sense of cause and effect within their environment, it is important that they play with toys that clearly display a cause and effect relationship. Also, tactile interaction provides them with opportunities to learn about their environment. The top surface of the play table provides the child with four different cause and

effect games which are brightly colored, making them interesting to the child. The Plexiglas and water bin surfaces allow the child to experience various tactile sensations.

TECHNICAL DESCRIPTION

Although the play table was designed for cerebral palsy patients aged one to three years, it could be stimulating and recreational for children without cerebral palsy as well. The main design requirements of the table were: 1) it had to be safe, i.e., having no sharp surfaces or exposed electrical wiring; 2) it had to be colorful and appealing to a small child; 3) the pieces used with the table had to be specially shaped so the child could handle them successfully.

The top portion of the table was constructed of $\frac{3}{4}$ -inch thick pine, painted red, and shaped as a $16\frac{1}{2}$ by 24 by 2-inch hollow rectangular box with a hinged top. Hardboard with a thickness of $\frac{1}{4}$ inch was used for the bottom of the box; as it might contact water on the Plexiglas surface beneath it, it was primed with an oil-based primer. All electrical wiring for the top surface was placed inside this box. The hinged top of the box allows easy battery and electrical servicing. The top of the box contains six differently colored activities. Three of the activities involve the placement of a green circle, red square, and blue triangle into their appropriate routed spaces on the box. A $\frac{7}{16}$ -inch diameter peg extending from the bottom surface of each shape fits into countersunk, $\frac{1}{2}$ -inch diameter holes in the top of the box and throws a mechanical lever arm switch. When all three of the switches beneath the shapes are thrown, a sound card is activated and a song is played. The fourth activity operates by the same mechanism: when 12 yellow pegs are placed into 12 holes at the points of a yellow star, 12 mechanical lever arm switches are thrown and a red LED inset in the table top is activated. The pegs were created by inserting $\frac{7}{16}$ -inch wooden dowels into wooden hobby candle cups with hot glue. Wiring is connected to the LED via long gaiter clips to allow

easy circuitry/battery servicing when the top is opened on its hinges. The fifth and sixth activities are purchased toys (Fisher-Price® Lights 'n' Sounds Phone and Playskool® Barney Poppin' Pals) which have been set into routed shapes on the top of the box. To secure the top of the box to the rest of the table, ½-inch diameter holes have been drilled in the bottom corners of the box to accommodate 7/16-inch diameter pegs that extend from the base of the table.

To secure its position, the Plexiglas layer of the table also has ½-inch diameter holes drilled in its corners to accommodate the pegs extending from the base of the table. Strips of 1/16-inch thick foam were glued on top of the corners of the Plexiglas to prevent damage to the Plexiglas by the top box. The bottom of the Plexiglas was primed with water-based primer and painted white so the surface beneath the Plexiglas would not be visible to the child.

When the red top box and Plexiglas are removed, the yellow ½-inch thick plywood surface containing a water bin is visible. The bin used was a 14 ½ by 10 ½

by 2-inch Baker's Secret® lasagna pan. A 14 ½ by 10 ½-inch rectangle was cut from the center of the plywood, and a slightly larger rectangle was routed ¼ inch deep surrounding the cut, allowing the pan to be completely inset in the plywood. The plywood was nailed to a 1 by 2-inch pinewood frame and painted with yellow oil based paint.

Beneath the plywood, the blue painted PVC pipe legs of the table were anchored to the corners of the pine wood frame with pieces from a table leg anchoring kit. The legs were capped with PVC caps to add stability. Additional information concerning the table's adjustable PVC pipe legs can be obtained from the designer.

Total project cost was about \$200.

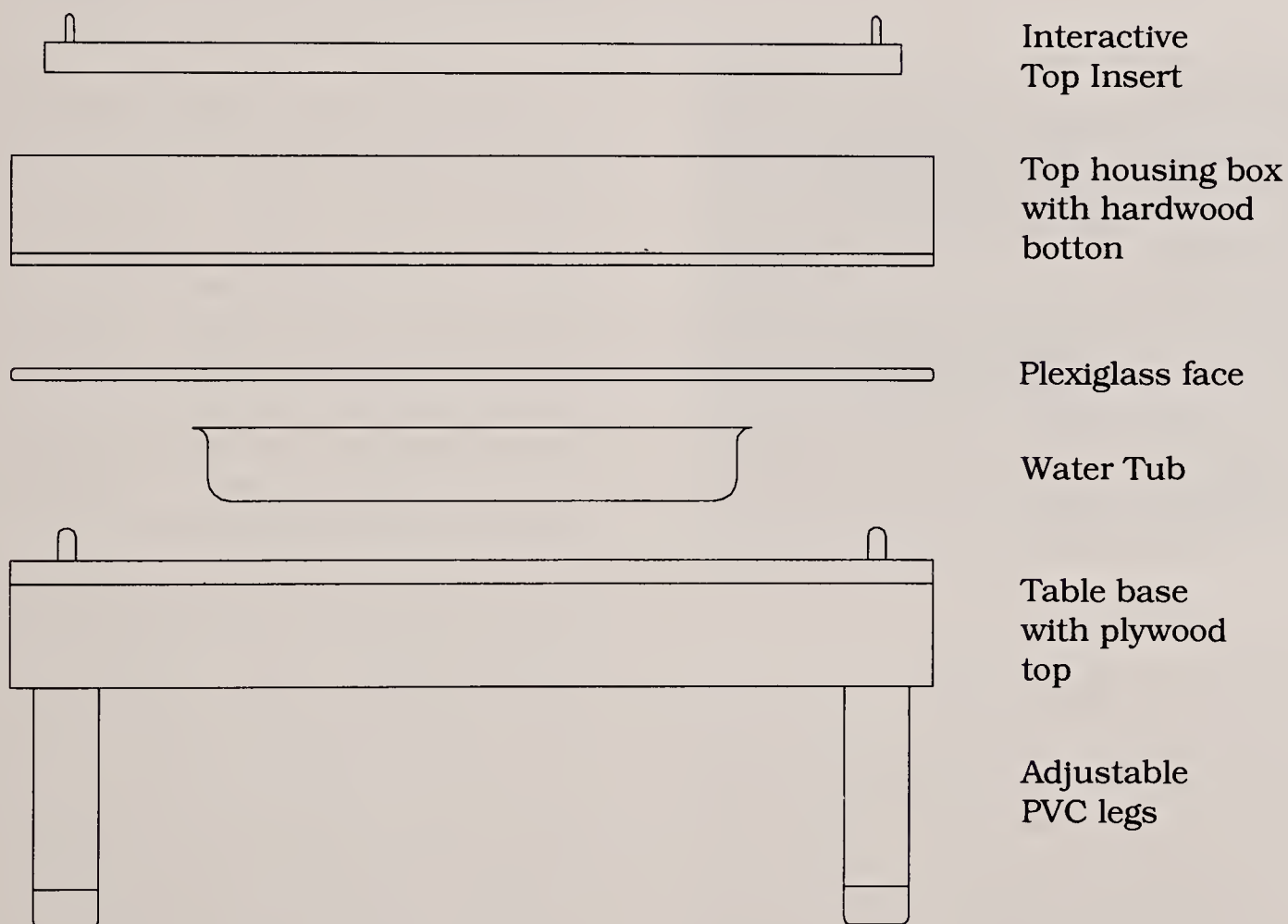


Figure 7.14. Disassembled Table, Side View.

A Speech Therapy Aid For Developmentally Impaired Children

Designers: Shannon Dunphy, Marisa Medrano, Karl Schneider
Client Coordinator: Janette Hughes, Speech-Language Pathologist
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Bioengineering Program
Texas A&M University
College Station, TX 77843

INTRODUCTION

A four compartment opaque box has been constructed for use in speech therapy. An object is placed inside each of its four compartments. A one-way opaque mirror conceals each object. Four switches control a light source for each individual compartment. When a switch is activated, the light turns on inside its corresponding compartment, and the toy inside is revealed. When the switch is no longer depressed, the light turns off and the mirror again becomes opaque, concealing the object inside the compartment.

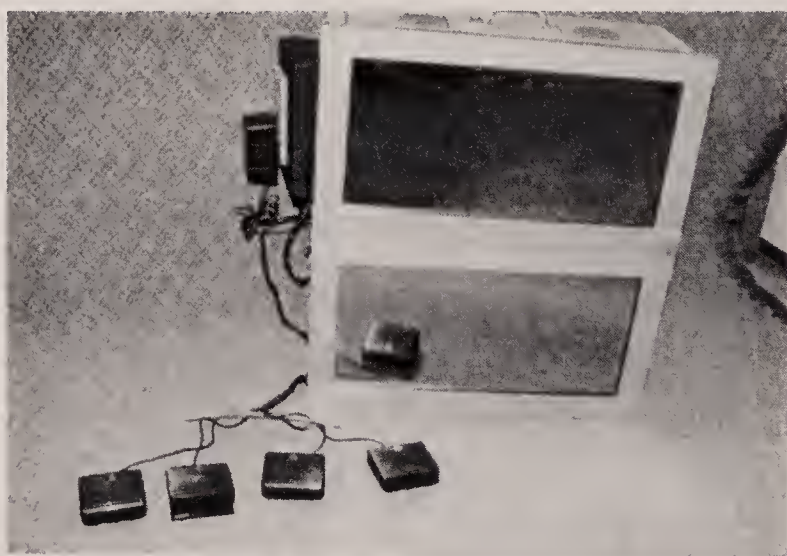


Figure 7.15. Multi-Station Opaque Box.

SUMMARY OF IMPACT

This multi-station opaque box will be used to teach children who are developmental handicaps, such as those associated with cerebral palsy or spina bifida. Children may learn picture-object association by matching a two-dimensional photo with the corresponding three-dimensional object. The development of these skills is crucial to the language development of a child.

In addition, this box can be used to stimulate development of learning disabled students. Some people with learning disabilities are incapable of matching a three-dimensional object with a two-dimensional picture; if such a person is given a picture of an object, he or she may be unable to select that object from a group of objects. Visual stimulation may improve matching capabilities. The teacher or therapist will show a picture of an object to the student and then reveal the corresponding three-dimensional object within the opaque box. This sequence is repeated to stimulate the individual's ability to relate two-dimensional pictures to three-dimensional objects.

TECHNICAL DESCRIPTION

The opaque box is built with four compartments; its size is 32 by 16 inches. Tinted (one-way) glass is placed in front of each compartment so that the interior of each compartment will be visible when the compartment is illuminated. The compartment will become visible when there is more light inside the compartment than outside of it. When the light inside the compartment is turned off, the glass will appear opaque, so that the object is hidden. The one-way glass was coated with silicon to prevent breakage.

The structure of the box is made entirely of wood. The compartments are enclosed by wood on all sides except the front, which is covered by tinted glass. Each compartment has a separate light source, a 6 by 2.5-inch fluorescent bulb, providing ample illumination to allow visibility from the outside. All surfaces of the box were painted shiny metallic silver to scatter of the light. The light sources require 110 volts AC; for operator safety, the 110 volts AC must be isolated from the control switches. This is accomplished by using a 12-volt DC system to activate the lights. Relays are used to interface the 110-volt AC with the 12-volt DC.

Four individual pushbutton switches activate the lights in each of the compartments. Different objects are placed in each compartment. The switches are placed next to the pictures that correspond to the objects in the compartments. The child may look at the

picture, press the switch, and view the three-dimensional object seen in the picture. The approximate cost of the multi-station opaque box was \$275.

Object Association Window

*Designers: Joe Richter and Lauren Heitmann
Client Coordinator: Janette Hughes, Speech-Language Pathologist
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Bioengineering Program
Texas A&M University
College Station, TX 77843*

INTRODUCTION

An object association box has been designed for children with learning disabilities. The front surface of the hollow box consists of an opaque, voltage-activated LED screen. Upon activation, the screen instantly becomes transparent. Three-dimensional objects can be placed inside the box behind the opaque screen and can be revealed to the viewer by moving a toggle switch to the 'on' position.

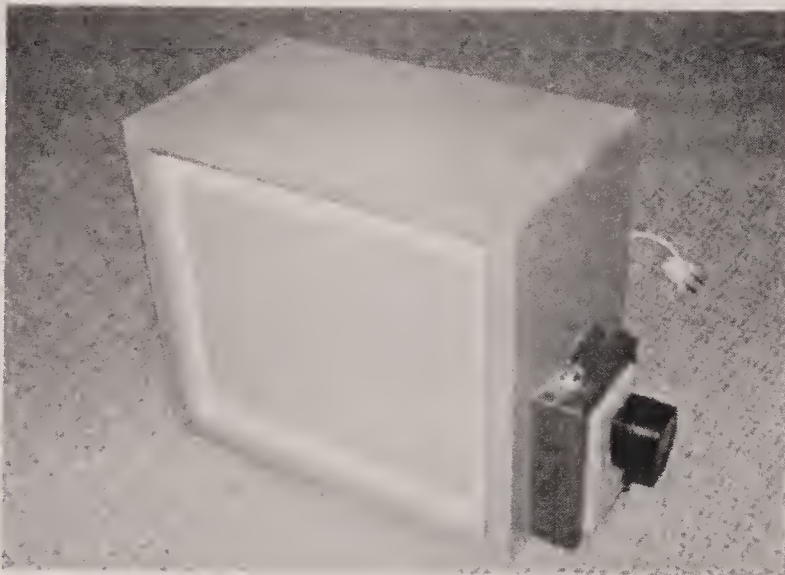


Figure 7.16. Object Association Window.

SUMMARY OF IMPACT

Children with learning disabilities often have difficulty associating two-dimensional representations of objects with their three-dimensional counterparts. Correct formation of these associations is crucial to optimal cognitive development. An object association box aids learning for children with association difficulties because it allows for hands-on, instant feedback in a game atmosphere. Consider the following scenario: a teacher uses multiple boxes and places different toys in each box. After showing the child the toys in the boxes by making the screen transparent, the teacher returns the screen to its opaque resting state. At this point, the teacher shows the child a pic-

ture of one of the toys. If the child correctly identifies the box containing the toy, the instructor can instantly reward him or her by allowing him or her to play with the toy. If the child's attempt is incorrect, the teacher can make the screen transparent again to refresh the child's memory and then resume the game.

TECHNICAL DESCRIPTION

The construction of the object box association is fairly simple. The 12.5 by 7.5 by 11-inch rectangular box consists of pieces of 0.25-inch hardboard nailed together. The LCD screen is the front surface of the box. Two pieces of 0.125-inch transparent plastic, which are the same size as the screen, cover the front and back surfaces of the screen. Rims of 0.5-inch molding nailed to the hardboard both in front of and behind the screen and plastics hold them securely in place. To facilitate the placement of objects, the box was left open in back. A 20-watt fluorescent lamp is attached to the inside top surface of the box with heavy duty Velcro. The cord powering the lamp is stapled to the inside surface of the box to prevent interference with objects placed inside.

The wires to and from the screen and lamp enter and exit the inside of the box via a 0.375-inch diameter hole of in the right front surface of the box. Covering this hole, a 4 by 1.5 by 5-inch plastic box is screwed into the outside surface of the hardboard. A toggle switch is embedded in the top of this box. When flipped, the switch allows 120 volts to reach the screen and the lamp. A grounding outlet and cover plate are embedded in the outside vertical surface of the plastic box. A nine-volt adapter is plugged into the outlet. A two-foot, 16-gauge cord exits the bottom of the plastic box and is connected to a 120-volt plug.

When plugged into a 120 volt providing socket, the 16-gauge cord powers the nine-volt adapter. The toggle switch is connected in series with the adapter. When the switch is in the 'on' position, the adapter

powers a 120-volt relay with nine volts. When activated, the relay connects the circuit between the 120-volt live wire and the screen and lamp, collectively.

Total project cost was approximately \$145.

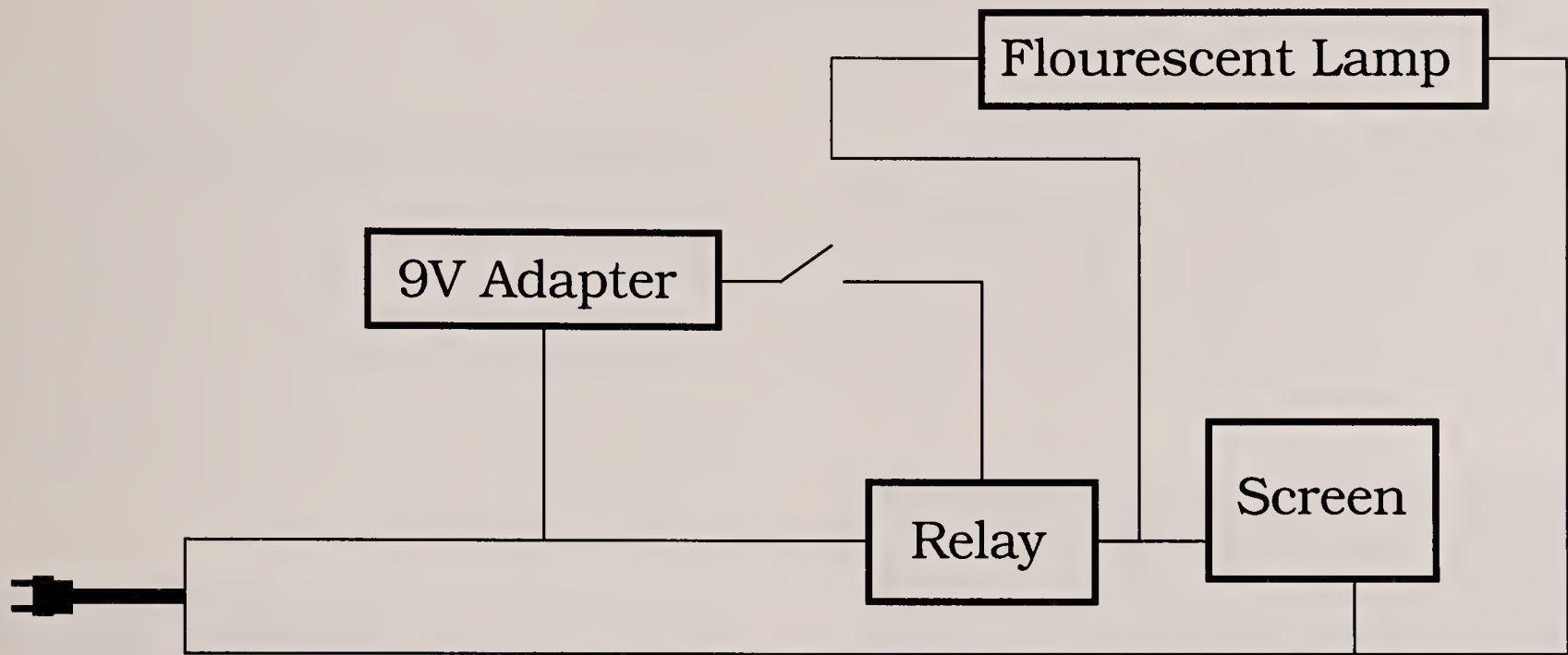


Figure 7.17. Electronic Block Diagram for the Object Association Box.

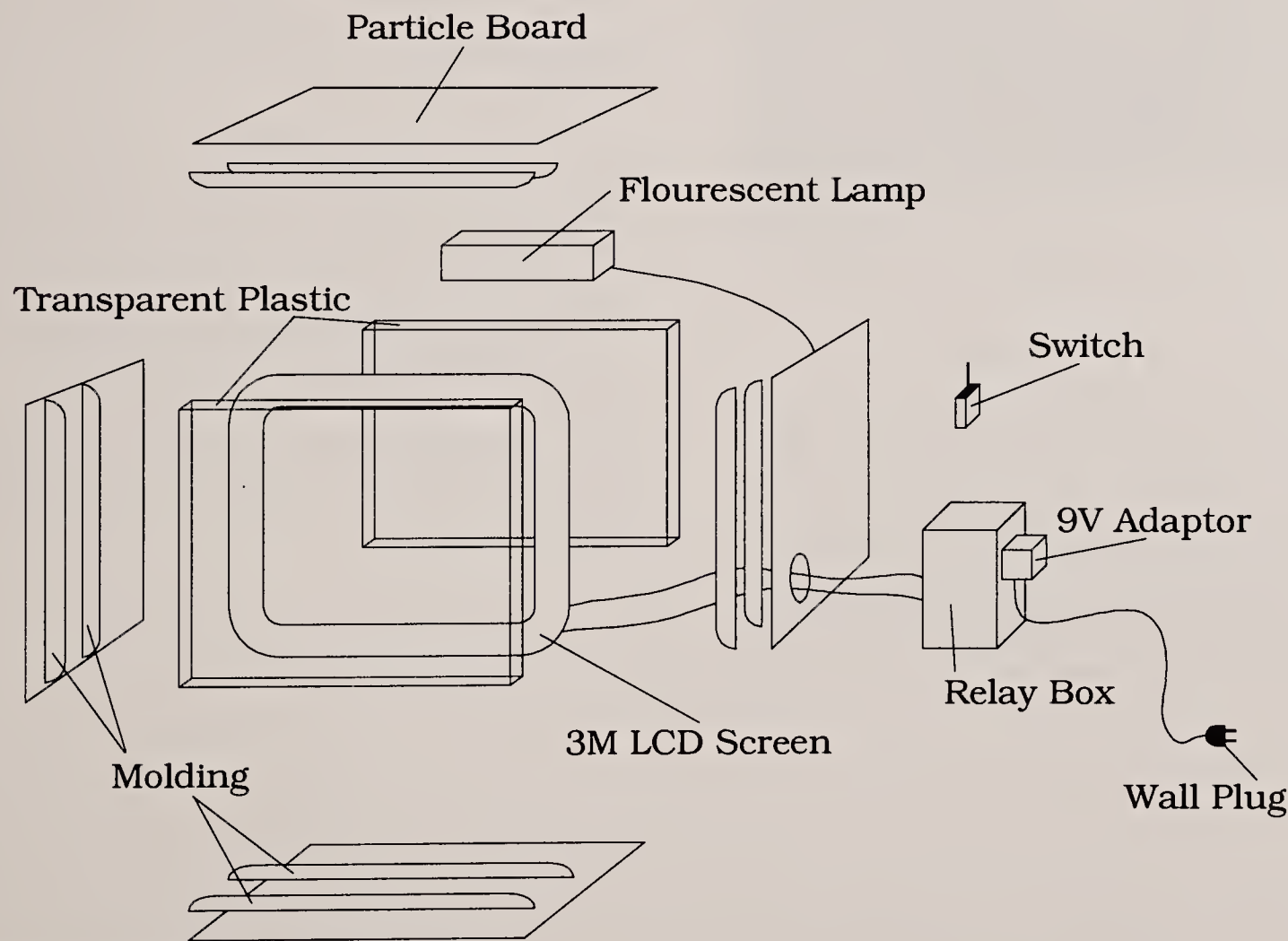


Figure 7.18. Hardware Assembly Diagram.

Multi-Function Switch

*Designers: Darren Bell, Robert Nichols
Client Coordinator: Greta Cherry
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Bioengineering Program
Texas A&M University
College Station, TX 77843*

INTRODUCTION

This novel switch is large and easy to operate so that young children will be able to utilize it relatively easily. When activated, the switch lights up, a colorful wheel rotates, and train sounds are produced. There is also an external jack so that additional toys may be operated with the switch.

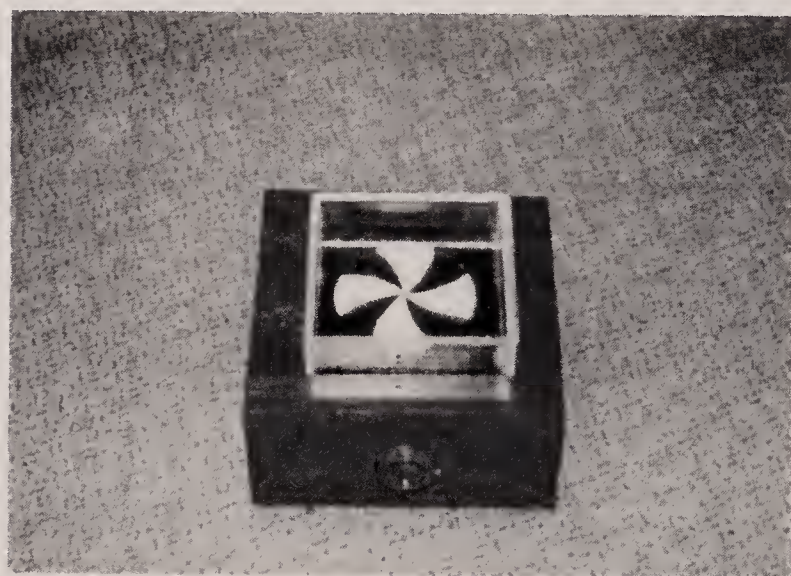


Figure 7.19. Multi-Function Switch.

SUMMARY OF IMPACT

This switch design allows the child to see the pattern of cause and effect. When the child pushes down upon the large switch, he or she is immediately rewarded with auditory and visual stimulation. This large switch is ideal for children who do not possess fine motor control skills. Depressing any area upon the big switch will result in lights blinking, the wheel rotating, and train whistles sounding.

TECHNICAL DESCRIPTION

The switch has a square Plexiglas top. Four locking single pole switches are found under the flanges of the Plexiglas surface; one is located at each corner. Only one of the four switches must be connected to the circuit to activate it. This alleviates problems that might be produced if all four switches had to be simultaneously activated; many users will not depress the Plexiglas top uniformly, causing fewer than four switches to be activated.

There is a small toy motor, powered by a single AA battery, which spins a colored wheel. Eight blinking LEDs are powered by three additional AA batteries. The batteries must be replaced when the LEDs light up but no longer blink as they should. The eight LEDs are all wired in parallel to each other and to the power source.

The sound is powered by four additional AA batteries. A four-pole six-volt relay is also powered by these four batteries. The relay was added so that the jack, lights, sound, and motor are all contained in separate circuit paths. In this manner, the lights, sound, and motor cannot draw power from any toy that may be connected to the external jack.

A total of eight batteries are used for this switch. All of the batteries are located on the bottom of the switch.

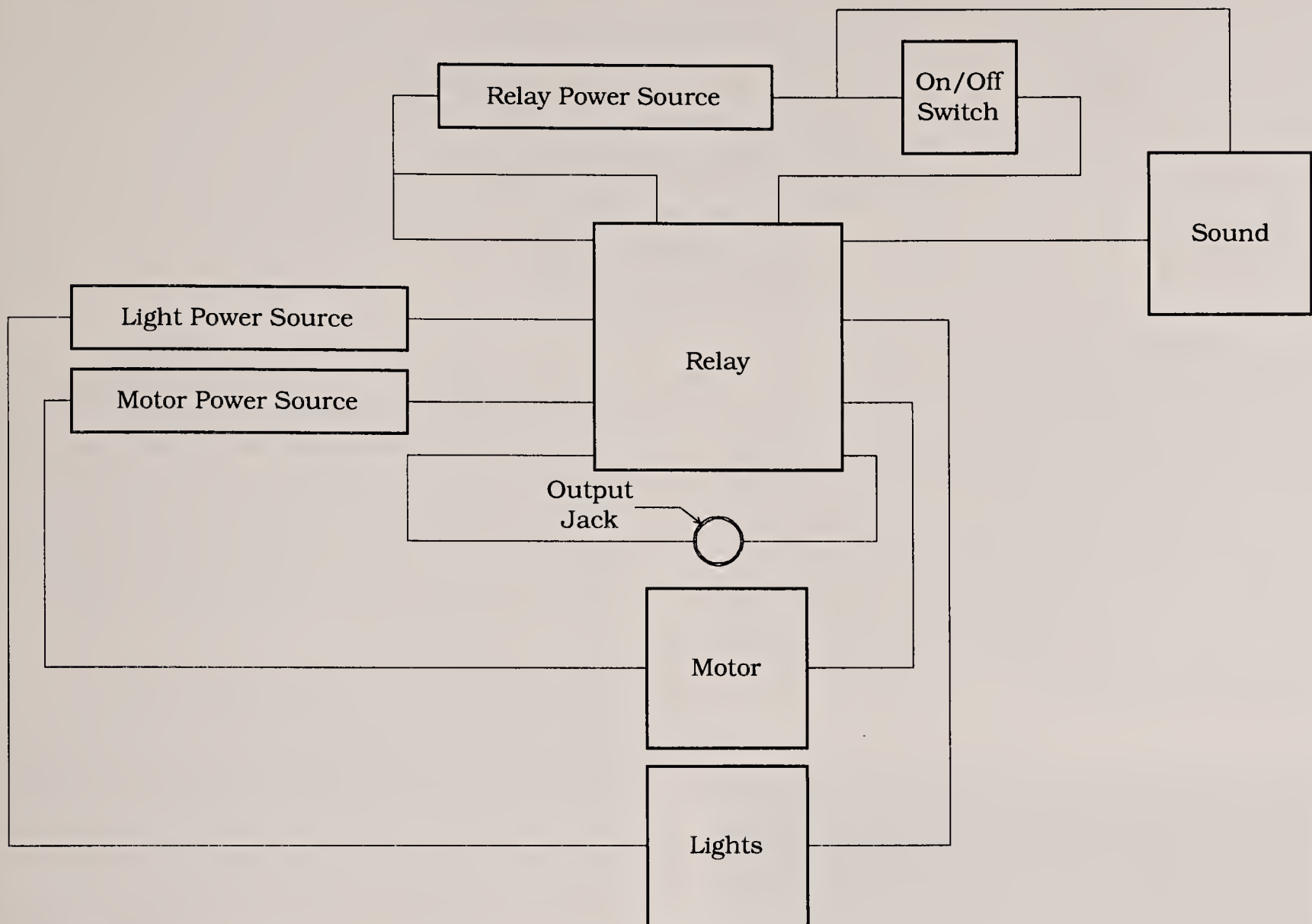


Figure 7.20. Multi-Function Switch Electronic Block Diagram.

Two-Stage Switch

Designers: Darren Bell, Robert Nichols
Client Coordinator: Kathy Moody
United Cerebral Palsy of Greater Houston
Supervising Professor: W.A. Hyman
Bioengineering Program
Texas A&M University
College Station, TX 77843

INTRODUCTION

A two-position switch suitable for mounting on a wheelchair and use as a head switch was designed. There are two external 1/8-inch jacks that provide an interface for the device to be operated by the switch. A television remote control was adapted for use with the switch. There are six functions on the remote control and six corresponding remote control jacks. The user may decide which two functions will be controlled by the switch.

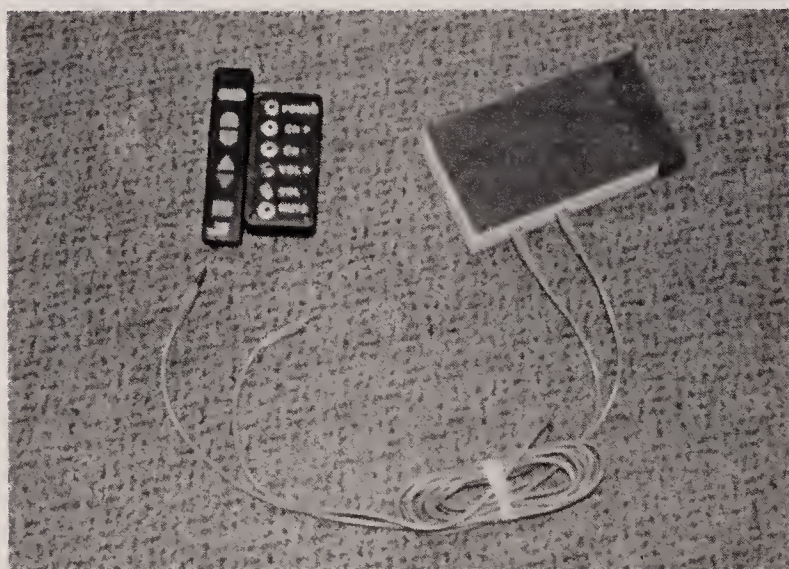


Figure 7.21. Two Stage Switch, Utilized with a Television Remote Control.

SUMMARY OF IMPACT

The two-position switch concept simplifies the use of a head switch for people who do not possess motor control skills that would enable them to activate a switching mechanism with their limbs. Patients with quadriplegia may find this head switch extremely useful since it would enable them to control a device through head movement. The two-position feature enables them to control two separate functions through a single switch. The traditional one position switch would necessitate the presence of two separate head switches for this purpose. The user would be

forced to move his or her head from side to side in order to control two functions. The single two-stage head switch is easy to mount and is much less bulky; the user need only activate one switch in order to control two separate functions. For example, the user can use the functions of channel up and channel down through the same switch. This gives the user a much greater degree of control over his or her activities.

TECHNICAL DESCRIPTION

The switch is entirely contained in a small project box. There is a thin metal plate attached to the box, with a hinge that serves as a lever to operate the switch. Three momentary contact switches are located under the plate. As the plate is depressed, these switches are closed sequentially. Each of the three switches controls the operation of a five-volt single-pole double-throw (5V SPDT) relay. The first switch operates the first jack. When the second switch is closed, the power is disconnected from the first relay, thus opening the circuit containing the first jack. The third switch controls the operation of the second jack.

One 220 μ F capacitor was placed across the terminals of relay three to provide a slight delay in the re-activation of the first function as the switch lever passes from the second function back to "off". This prevents the first function from being activated when the user releases the switch after using the second function.

When the switch is operated, the first click indicates activation of the switch's first function. The second click signals deactivation of the first function, while the third click indicates activation of the second function.

The approximate cost of this two-stage switch was \$40.

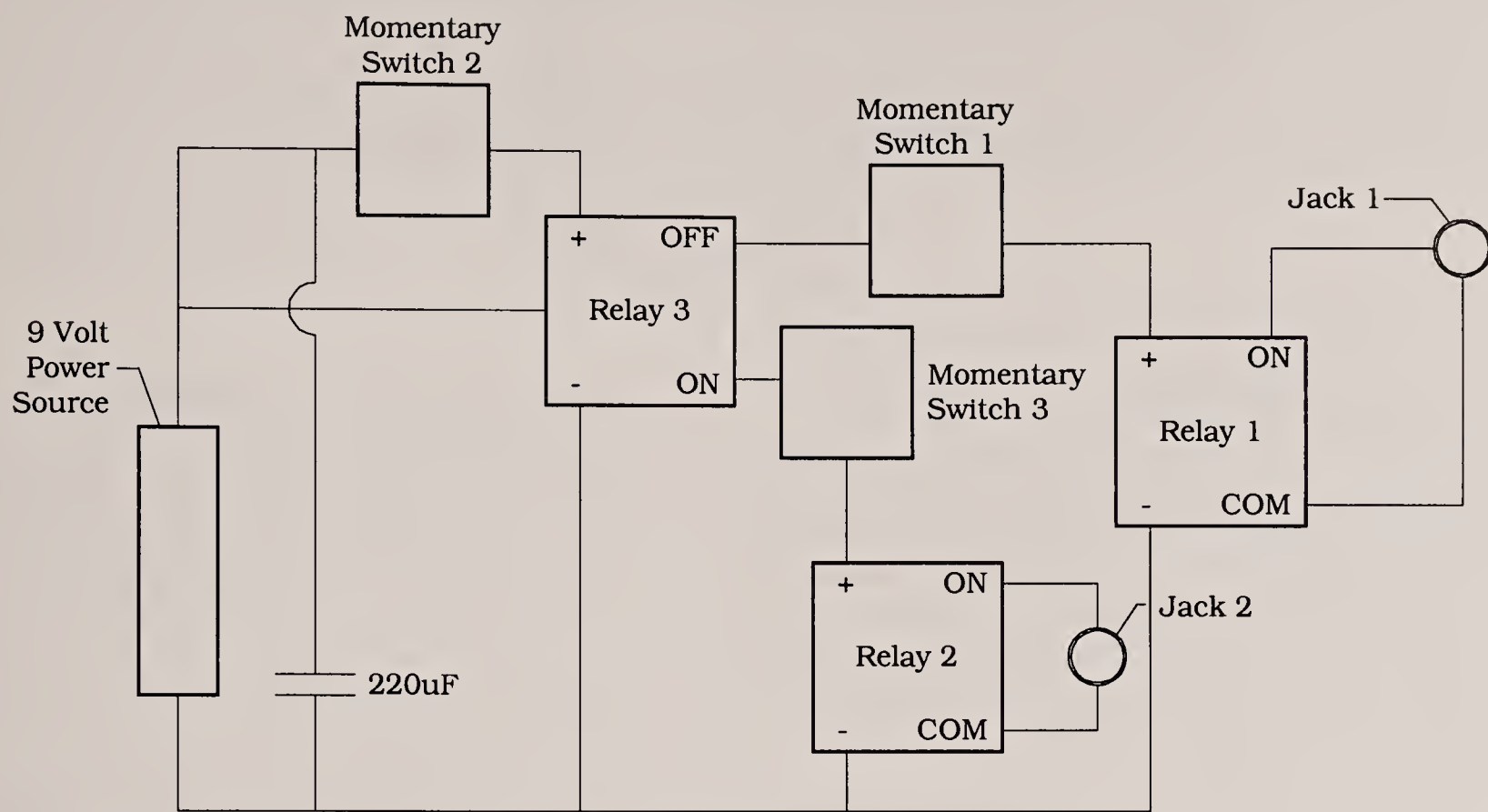


Figure 7.22. Two Stage Switch Electronic Block Diagram.

An Adapted Tape Recorder

Designers: Casey Stevenson, Marisa Medrano

Client Coordinator: Trish Peddicord

Special Education Department, Bryan (Texas) Independent School District

Supervising Professor: W.A. Hyman

Bioengineering Program

Texas A&M University

College Station, TX 77843

INTRODUCTION

An adapted tape recorder with switches has been designed for a student in a special education program in Bryan Independent School District. The client has Rett Syndrome, a severe neurological disorder that primarily affects females and leads to a variety of problems, the most severe being apraxia. These patients exhibit the will to move but have difficulty engaging in movement.

A stock tape recorder was modified to allow the music therapist to choose one of two modes of operation. In the "on" mode, the stop, play, rewind, and fast forward keys are operational. In the "off" mode, only the stop and play keys function.

A standard on-off switch was designed to activate only the play function of the tape recorder. After pushing the play key, the therapist inserts the switch jack into the remote output of the tape recorder. This allows the play function to be activated using the on-off switch.



Figure 7.23. The Adapted Tape Recorder.

SUMMARY OF IMPACT

Many children with Rett syndrome become frustrated as a result of their inability to communicate. Music has a calming effect and is used as an effective communication tool. Previously, the client fumbled with tape recorder keys during music therapy sessions and at times inadvertently erased her music tapes by accidentally pushing the record key. The adapted recorder allows the therapist to select between two modes of operation when working with the client. In the "on" mode, the recorder can be used with all of the standard functions; in the "off" mode, only the play and stop functions work. Additionally, the eject button was moved to the side of the recorder. The recorder can be used with either the standard on-off switch or the modified on-off switch, both of which allow the play function to be alternately turned on or off when the play key is depressed. The device meets the needs of many clients without full motor control of their upper extremities.

Students with cerebral palsy also work with music therapists. Many of these students are unable to exert the constant pressure needed to activate the tape recorder's existing momentary contact switch. The conversion of the switch to an on-off alternate action switch enables patients to activate and deactivate the play function by alternately pressing the contact area.

TECHNICAL DESCRIPTION

The adapted tape recorder was designed to comply with the following specifications: 1) it must be portable and durable; 2) the therapist must be capable of easily switching between the two operation modes; and 3) the function keys must be easily actuated by the patient.

The tape recorder was disassembled, and individual keys were disconnected. Holes were drilled through the record, play, stop, and pause keys approximately 0.4 centimeters from the leading edge. Steel pins were

placed through the holes of adjacent keys (record and play, stop and pause). This adjoins the two keys and in effect combines the two keys into a single key. Color-coded keypads were glued to the tops of the pairs of modified keys. Lever arms of the record and pause keys were cut off to disconnect them. This resulted in one functional play key and one functional stop key, each with a large surface area, and unmodified rewind and fast forward keys.

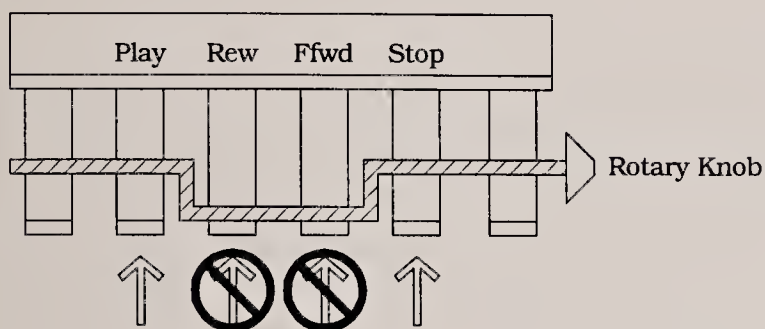


Figure 7.24. Modified Tape Recorder Keys.

A very thin metal rod was pre-bent to the shape shown in Fig. 8.25. Two holes were drilled on each side of the tape recorder, in which the rod is allowed to rotate. In its proper position, the rod extends slightly beyond one side of the recorder to allow the attachment of a rotary knob. In the "off" mode, the

knob is rotated such that the flanged section of the rod prohibits the movement of the rewind and fast forward buttons, but allows movement of the play and stop mechanisms. The eject function was originally combined with the stop function on a stop/eject key. The normal ejecting mechanism was disabled and replaced with a slide switch located to the side of the recorder.

The standard on-off switch was easily made by drilling a hole in the top of a plastic electrical box and fitting it with a standard alternate action switch. The switch is wired with a 1/8-inch jack but can be fitted with an adapter if necessary. The modified on-off switch was made from a pre-existing momentary contact switching device with a large contact surface area. A standard alternate action switch was fitted below the plastic contact surface by drilling a hole in the base of the device and connecting it to existing wires. A corresponding hole was made in a plastic electrical box, and the device was secured to the top of the box with screws, thus concealing the protruding portion of the switch.

The approximate cost of the adapted tape recorder was \$55.

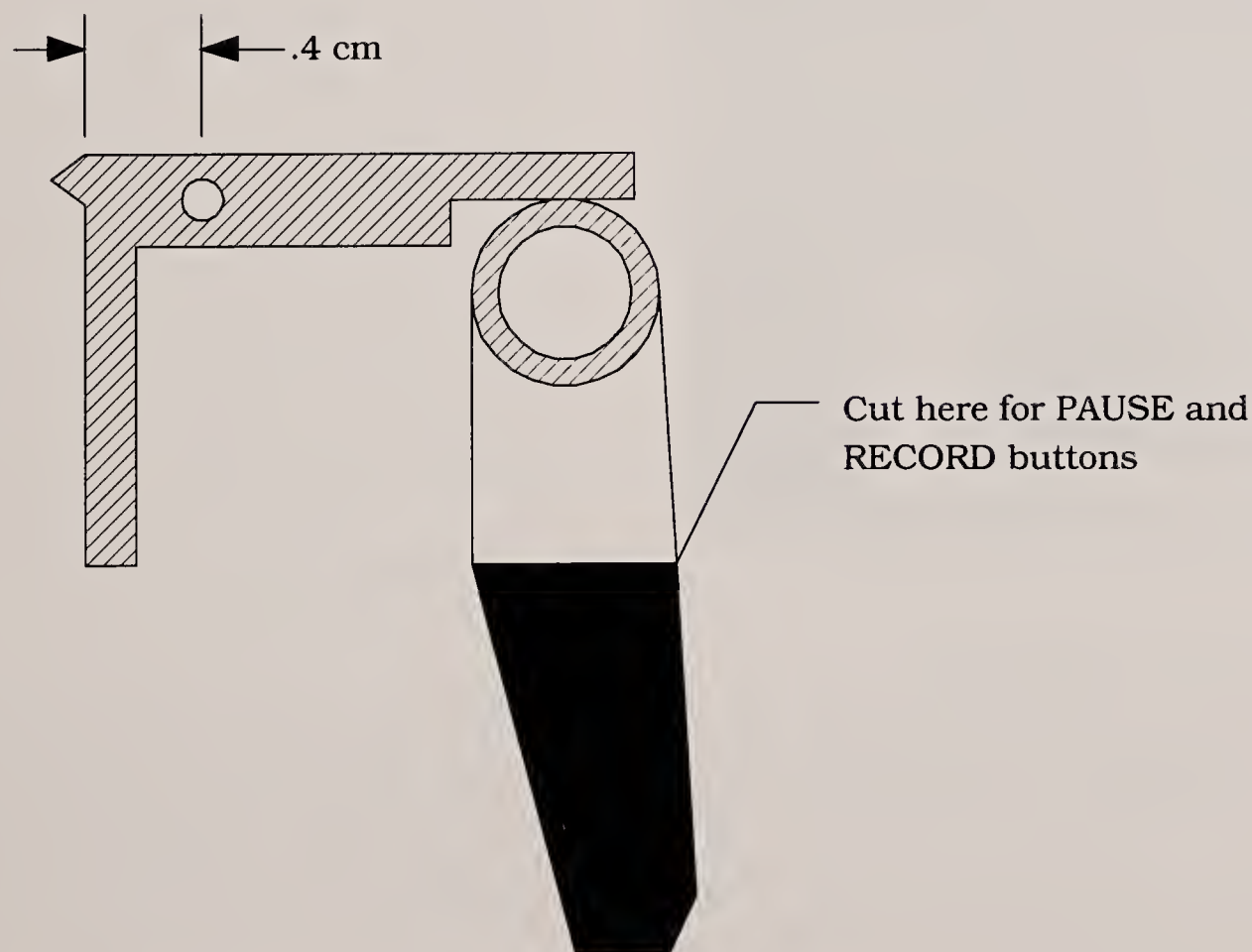


Figure 7.25. Rotary Knob Allowing 'On' and 'Off' Mode Alternation.

Touch Sensitive Jack-In-The-Box

Designers: K. Michelle Davis, Shawn Kollatschny

Client Coordinator: Maureen Haggerty

Crockett Elementary, Bryan (Texas) Independent School District

Supervising Professor: W.A. Hyman

Bioengineering Program

Texas A&M University

College Station, TX 77843

INTRODUCTION

Children with limited motor skills often have difficulty operating buttons and switches. Play with toys is important for fostering learning about cause and effect relationships, improving motor skills, and giving children a sense of control. Several types of mechanisms have been designed to help children with disabilities activate toys on their own. Heat sensors, motion detectors, traction pads, and touch sensitive mechanisms have been used for this purpose.

A jack-in-the-box was modified for an eleven-year-old boy with limited motor skills. It was made to eject when he touches a keypad, thereby reinforcing his association of touching the pad with an action. The jack-in-the-box music is not necessary to achieve this objective.

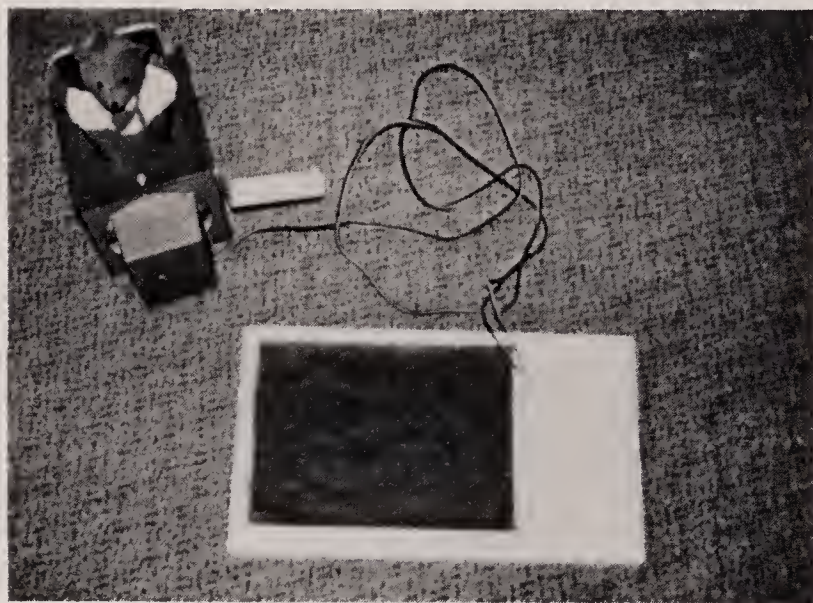


Figure 7.26. Touch Sensitive Jack-In-The-Box.

SUMMARY OF IMPACT

Due to the client's limited motor control, the touch sensitive pad has a large surface area over which to place his hand. In addition, it is activated by even a very light touch.

The client coordinator requested that the jack-in-the-box maintain its usual mode of operation, through the child's turning of the handle. A larger handle was therefore placed on the box so that the child could hold the handle with adult assistance. The jack-in-the-box was specifically chosen for this project because the child reacts positively to its action by smiling and laughing.

The child's learning of cause and effect relationships will be enhanced as he plays with the jack-in-the-box. Turning the box's wooden handle with adult assistance will help to develop motor skills and coordination. The child will be amused by the toy and will feel a sense of achievement and fulfillment upon being able to operate a toy independently, emulating the activities of his classroom peers.

TECHNICAL DESCRIPTION

The jack-in-the-box has a latch that was easily modified. The actual latch contained a center hole that enabled the designers to physically attach a wire to the latch. The wire was then connected to the solenoid pin by running the wire down the inside wall of the box and out of a pre-drilled hole located halfway down the side of the box. The solenoid was mounted to the outside of the box, and a plastic cover was placed over it for safety. A small hole was drilled in the bottom of the plastic cover, which allowed the electrical wires that powered the solenoid to run from the jack-in-the-box to the touch sensitive pad. When the circuit is connected, the solenoid is triggered; this action tightens the wire, pulls the latch open, and activates the jack-in-the-box.

An 8 by 12 by 1-inch wooden board forms the base board for the project. The battery compartment and touch sensitive pad are mounted to this board. A nine-volt battery activates the solenoid and is mounted in a case adjacent to the pad for easy replacement.

The touch sensitive pad was made with two plates covered in electrical conducting tape, and a copper wire coiled underneath. Four small springs hold the plates apart. The slightest pressure on the top plate connects the circuit and controls the jack-in-the-box. Quarter-round molding was placed around the pad to keep children's fingers from touching the electrical tape. A vinyl pad was placed over the top plate to keep children protected from electrical shock.

A large wooden handle with a one-inch diameter was placed over the original handle of the jack-in-the-box. The handle is long, allowing the boy's hand to fit easily around it.

The overall cost of the touch sensitive jack-in-the-box is approximately \$40.

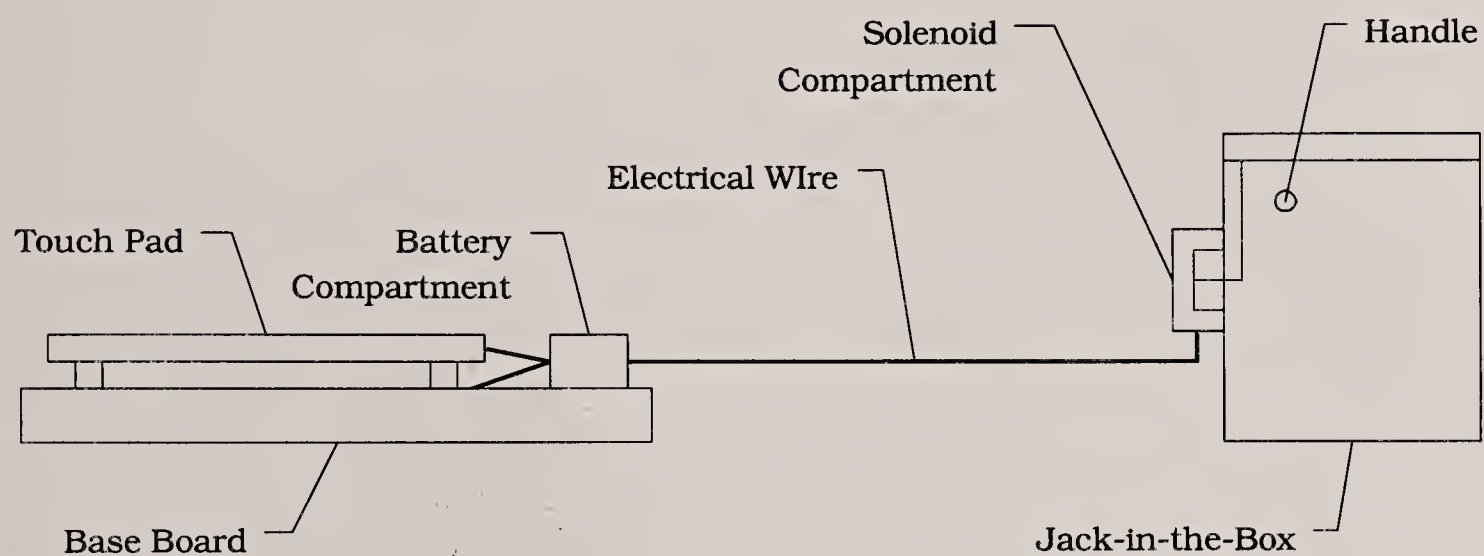


Figure 7.27. Touch Sensitive Jack-In-The-Box Schematic



CHAPTER 9

UNIVERSITY OF DELAWARE

**School of Engineering
Department of Mechanical Engineering
Newark, Delaware 19716-3140**

Principal Investigator:

*Dick Wilkins (302) 831-2421
wilkins@me.udel.edu*

Wheelchair Raiser

Designers: Jason Spisak, Matt Scarborough, Kabie Henderson, Eric Mei

Client Coordinator: James Siam

Advisor: Ralf Tschirschnitz

Supervising Professors: Dr. A4 Keefe, Dr. D. J. Wilkins

University of Delaware

I26 Spencer Lab

Newark, DE 19716

INTRODUCTION

This device addresses a height disadvantage endured by wheelchair users. It allows the user to raise the chair and him or herself to the approximate height of a standing person. The device is attached to a normal wheelchair, without interfering with the original functions of the chair. It is attached with clamps, such that it can be easily removed and re-attached. The system is fully self-contained, requiring no assistance from anyone other than the user. The device was kept as light as possible, so that the user is not forced to transport excess weight. The design ensures that the chair remains level throughout operation, regardless of the user's position. A device for a similar function currently available on the market costs over \$13,000 - more than ten times the cost of our design - and raises the user only eight inches, compared to 15 inches with the present design.

SUMMARY OF IMPACT

A person in a wheelchair is faced with new challenges every day. Lifting the person up 15 inches allows an individual to sit at the height of a normal standing person. This reduces problems in several situations in the home and workplace.

TECHNICAL DESCRIPTION

The design employs four hydraulic cylinders to lift the chair, with four more cylinders assembled for a pump. Primary criteria were: (1) the need to ensure even deployment of the lifting device under uneven loads; and (2) stability.

The pump was composed of four cylinders assembled in parallel, all driven by the same ball screw. This design, with four points on the floor, allowed for more stability than three, and was actually less expensive because of additional adaptations required by a three-cylinder system. The cylinders were threaded on both ends, with the ball nut and the threaded ends

of the rods rigidly attached to the same steel plate. The backs of the cylinders were fixed on the other end to a second steel plate sandwiched between two thrust bearings at the end of the ball screw. A third plate was added for additional rigidity. All four pump cylinders move together.

Since hydraulic fluid is incompressible, the lifting cylinders must move together with the pump. The pump assembly must be rigid, and the plates must remain parallel. If they do not, the cylinders may bind. To address this issue, deflection in the plates under a load was reduced to a maximum of 0.016 inches under worst case loading conditions. ("Worst case loading," here, refers to the weight of a hypothetical 300-pound person, plus the 81-pound weight of the chair, plus the 47-pound weight of the lifting system, all with a center of gravity directly over one of the cylinders.)

The fixture points for the attachments were determined by the geometry of the chair. Steel clamps were used as a base for welding. In the rear, the locations of the cylinders were constrained by the need not to interfere with the ability of the chair to tilt back — such as required for maneuvering onto a curb — while remaining as stable as possible. Therefore, the cylinders were placed as far back as possible, while keeping the feet on the cylinder within a radius of 12 inches from the hub of the wheel. With one-inch clearance off the ground, that point is approximately 4.8 inches behind the axle. The locations of the top rear clamps were in turn determined by geometry once the bottom was set.

The system is powered by an electric motor mounted on top of the pump assembly. The torque requirement is surprisingly low, much less than most hand drills provide. The motor is permanently mounted with a switch located on the armrest of the chair for easy access by the user.

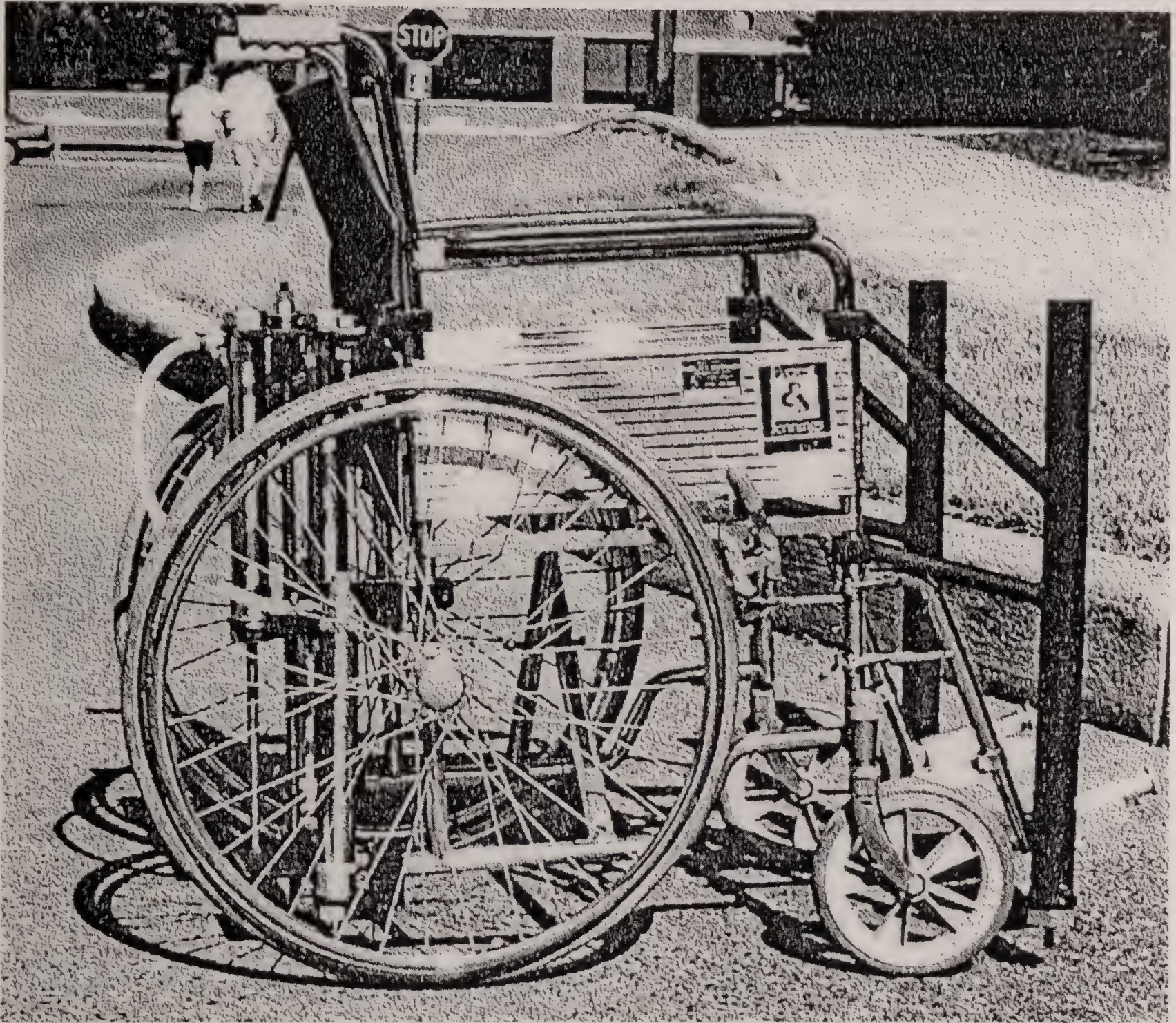


Figure 9.1. Photograph of the Wheelchair Raiser.



CHAPTER 10

UNIVERSITY OF TOLEDO

**College of Engineering
Department of Mechanical, Industrial and
Manufacturing Engineering
Toledo, Ohio, 43606**

Principal Investigators:

*Richard K. Irey, Ph.D., PE. (419)-530-8210
Mohamed Samir Hefzy, Ph.D., PE. (419)-530-8234
mhefzy@eng.utoledo.edu*

Tilting Platform For Wheelchair Access To Dental Surgery

Designers: Glenn Siddens, Alex Kominek, Patricia Eckelberry, Brian Colston
Client Coordinators: Dr. William Davis and Dr. Gregory Nemunaitis, Medical College of Ohio
Supervising Professors: Dr. Steven Kramer and Dr. Richard Irey
Department of Mechanical, Industrial & Manufacturing Engineering
The University of Toledo
Toledo, Ohio, 43606

INTRODUCTION

The objective of this project was to redesign, reconstruct, and install a second-generation working prototype of a lifting and tilting platform in a dental suite at The Medical College of Ohio (MCO) in Toledo. The platform was designed to accommodate a wheelchair or a regular dentist's chair, and is to be lifted and tilted to a prescribed position and orientation. The design is to be fabricated, installed, and used in a hospital setting. This project was started during the winter and spring quarters of 1995; a prototype was designed and constructed, with details reported in the 1995 book of engineering design projects (pp. 226-227). The first-generation prototype used a power screw that was driven by a gear motor, and was allowed only to tilt. The new prototype employs two pairs of scissors arms and a system of three hydraulic cylinders that allow lifting and tilting of the platform. This prototype is being evaluated for final installation.

SUMMARY OF IMPACT

Since its founding, the Department of Dentistry at MCO has treated patients in wheelchairs. The department treats an average of three patients a day who are wheelchair-bound. Many such patients arrive directly from the hospital, some having intravenous tubes in both arms, with the tubes tied down to the wheelchair. Other wheelchair-bound patients do not feel comfortable being moved from their wheelchair to the dental examination chair. Still others, due to their general health, are not able to sit in a dentist's chair for the duration of an examination. It is thus much more practical for the patient and staff if the patient can stay in his or her wheelchair during the examination.

There are products currently on the market that allow patients to remain in a wheelchair and still be examined in a position that is suitable for the dentist. However, they only accommodate wheelchairs. Since

wheelchair-bound patients constitute only a fraction of the total number of patients treated per day in the department, it is not economical to devote an entire suite to wheelchair-only use. Therefore, an apparatus that lifts the wheelchair and tilts it backwards, yet still accommodates a regular dentist's chair, is an appropriate solution. A adaptive dental platform was thus designed, built and evaluated.

TECHNICAL DESCRIPTION

The main components of the system include bottom and top frames, a platform, a ramp (for rolling a wheelchair up on to the platform), a cart (to make the existing dentist's chair mobile), and a hydraulic system. The materials used to construct the components were selected for low cost, cleanliness, and performance. The fact that the system is going to be used in a hospital setting necessitates that all materials be kept clean and sanitary. The materials are also expected to carry various loads and be able to handle points of high stress.

The bottom frame, which is in direct contact with the floor, is made of four by four-inch stainless steel angles. Due to the routine cleaning of the dental suites, this material must be resistant to rust and strong enough to hold large loads. The top frame is made from four by four-inch hot rolled carbon steel angles. This material was chosen because it is potentially in less contact with water and is much cheaper than stainless steel, thus keeping costs down. The carbon steel is strong enough to meet specifications; it is painted to make it aesthetically pleasing. The top frame is kept level while being lifted by two pair of scissors arms as shown in Figure 10.1. The tilting platform is made from half-inch thick T6061 aluminum plate and is 30 inches wide by 40 inches long. T6061 aluminum is chosen because it is clean, corrosion resistant, lightweight, relatively inexpensive, and is strong enough for the expected loads. The ramp and

cart are also constructed from T6061 for similar reasons.

Due to the need for head and back support for the patient while tilted backwards, a backrest was constructed. It consists of two components: a pad and a frame to support the pad. The frame is made of one by one by 1/4-inch thick T6063-T52 extruded aluminum. The pad is upholstered plywood.

The mechanism used to produce the motion for the dental platform is one of the major aspects of the project. Cost, efficiency, cleanliness, noise, and overall performance were considered. In the first generation prototype, a power screw and a gear motor were selected (1995 NSF Senior Design Projects to Aid the Disabled, pp. 226-227). Evaluation of the first-generation prototype indicates that its overall performance was not satisfactory since it allowed only tilting of the platform. In this second-generation prototype, a hydraulic system was employed.

Because the overall height of the platform is one of the primary concerns, finding hydraulic cylinders that can fit into the platform and still perform the desired task is challenging. The cylinders must be small enough to fit into the initial height of the platform. At the same time, the initial angle of the cylinders must be great enough to withstand the force provided by the cylinders. Therefore, platform design entailed consideration of the dimensions of the hydraulic cylinders.

The major advantage of hydraulic cylinders is that they can perform all modes of motion with one power assembly. Because motors are expensive, the number of motors must be minimized. The first-generation prototype employed a power screw and a gear motor, but allowed only tilting of the platform. Another motor would have been required to allow for the additional lifting motion. An additional advantage of hydraulic cylinders is that they do not have an oily surface exposed except during the relatively brief times they are extended. Therefore, they are appropriate for a dental suite, in which cleanliness is of utmost con-

cern.

The dental platform has two modes of motion. The first mode is in the vertical direction. The second allows a rotation, or tilt, about a fixed point. Three cylinders were used to accomplish the total motion. Figure 10.2 illustrates the layout of the three cylinders employed in this prototype.

Two hinges at the fixed end and one cylinder midway out, on the free end (Figure 10.3) support the tilt platform. The initial angle on the tilt cylinder is approximately three and a half degrees. The initial angle is large enough for the cylinder to easily tilt the load. The two other cylinders and the two sets of scissors arms perform the lifting of the structure. The purpose of the scissors arms is to provide stability and to limit the motion of the platform in the vertical direction. The purpose of the cylinders is to lift the load. Two cylinders, instead of one, were used because stability is a larger concern for the lift platform.

Both lift cylinders must extend the same amount at the same time regardless of load or initial positions. If, at any time, the cylinders are at different angles, or if the load on one cylinder is less than on the other, they still have to extend together. Therefore, series cylinders are being used. Series cylinders entail two cylinders, a master and a slave. The fluid from the out port of a pump travels into the in port of the master cylinder. Then, the fluid from the out port of the master cylinder travels into the in port of the slave cylinder, and the fluid from the out port of the slave cylinder travels to the in port of the pump. There is also a bypass valve in the master cylinder, which allows the pressure in the overall line to equalize. Whenever the master cylinder reaches full stroke, the fluid from the pump is able to travel directly into the slave cylinder. Therefore, if the slave cylinder is a little behind in stroke length, the stroke is then equalized.

The cylinders are also double acting. If the cylinder is to be extended, fluid must be fed into the in port of

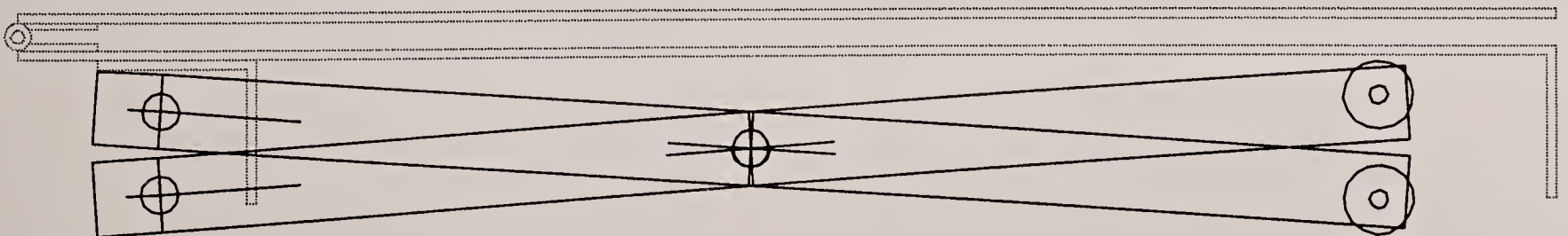


Figure 10.1. The Scissors Arms.

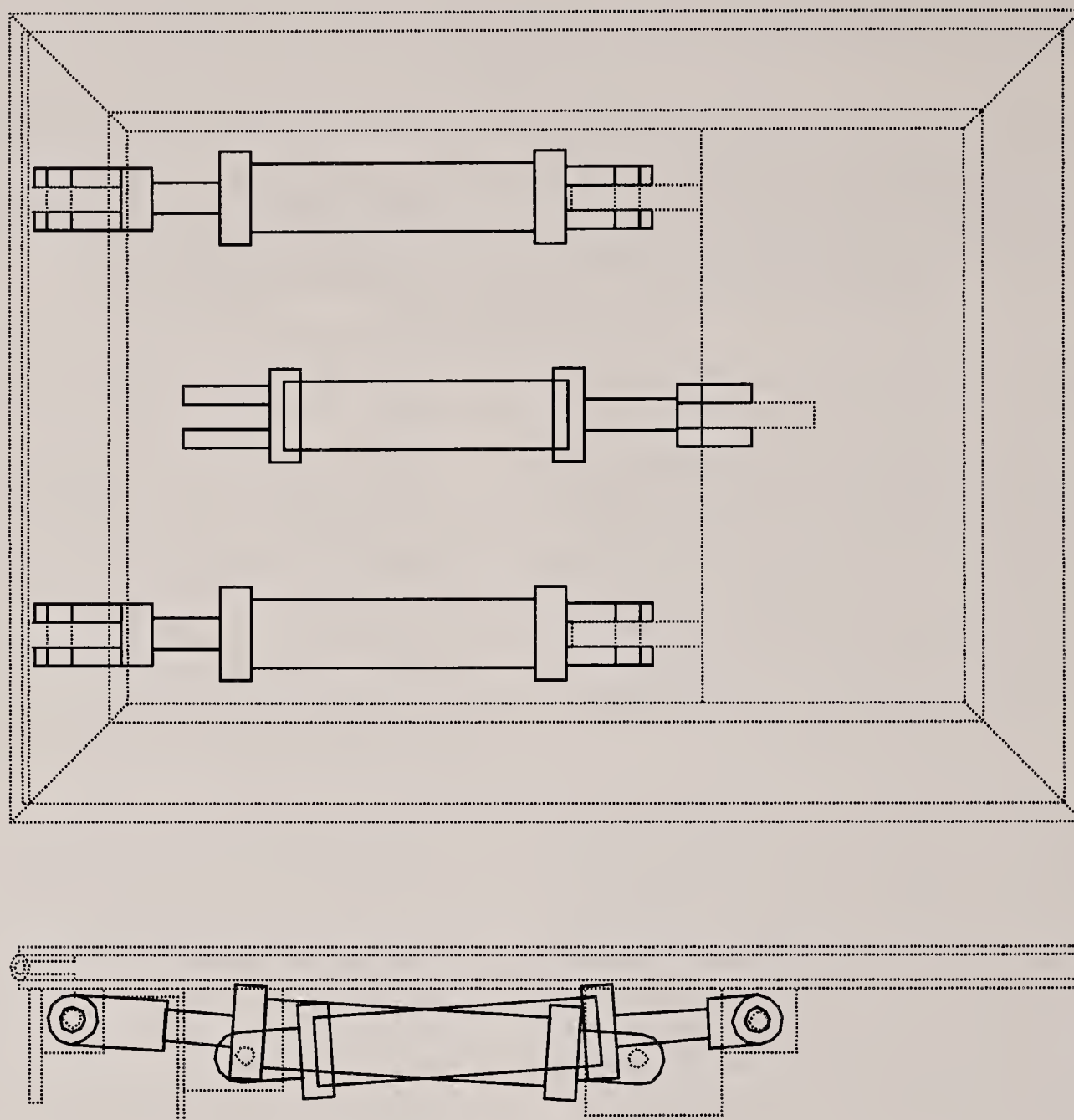


Figure 10.2. The Hydraulic Cylinders.

the cylinder. To be contracted, the fluid need only be fed into the out port of the cylinder. Thus, gravity does not help or hinder the operation of the cylinders. The major reason for selecting this type of cylinder is the amount of control gained. If a single acting cylinder were used, the lowering of the platform would have been dependent on gravity. Also, the speed at which the platform was lowered, or the angle of tilt, would not be able to be controlled. With double acting cylinders, the speeds of the cylinders are able to be set by the operator.

Figure 10.4 shows a flow diagram of the hydraulic system. The fluid from the pump is fed into a manifold, which then divides the flow between two valves. These two valves control the flow of fluid to the lift and tilt cylinders. Thus, the cylinders can be run all at once, or more preferably, one at a time. A manifold

makes the hydraulic circuit cleaner and allows for better operation. The valves are three position valves. One position directs fluid from the pump back to the reservoir. The second position directs fluid from the pump into the in-port of the hydraulic cylinders. The final position directs fluid from the pump into the out-port of the hydraulic cylinders. The valves also have control dials to control the speed of the fluid. There are separate dials for each position so that, for example, the speed for lifting the platform can be slow and the speed to lower the platform can be fast if desired.

Deflection of loaded dental cart: The calculations for the deflections of the dental cart include a 450-pound dental chair and a 442-pound person. The cart is made of T6160 aluminum and is 0.75 inches thick. The cart's dimensions include a lowered level that runs 26 inches long and 26 inches wide. This lowered

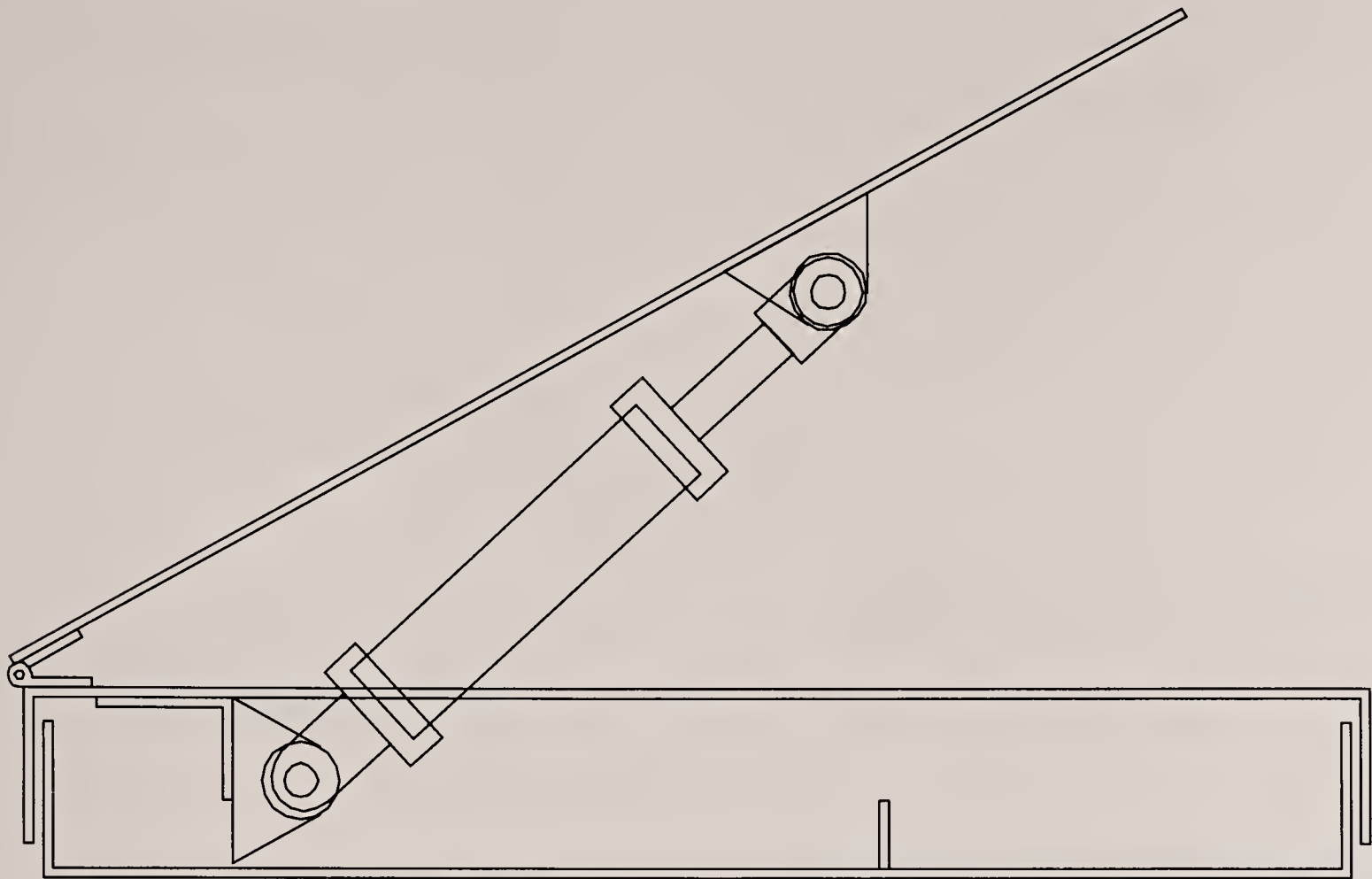


Figure 10.3. The Platform Tilted.

section allows the dental chair to rest closer to the ground while the raised ends allow for more space for more efficient casters. The base of the dental chair measures 25 inches in diameter and because of this, simple supports and a uniform load are assumed for the calculations. For a total load of 892 lbs., the maximum deflection at the center of the cart was calculated as 0.581 inches, and the maximum normal stress was calculated as 7370 psi. These calculations indicate that the maximum deflection is in the center of the cart at slightly more than one-half inch. The value of the maximum stress of 7370 psi is much less than the proportional limit of aluminum. The cart will thus not be permanently deformed when subjected to the load, and will return to its original flat shape when the load is removed.

Dental cart clearance over ramp: When choosing the length to height ratio for the ramp leading up to the dental platform a minimum ratio was desired to reduce the floor space and the weight of the ramp. The length to height ratio used is eight to one. This ratio was chosen to confirm with the U.S. Department of Transportation's *Guideline Specifications for Passive Lifts, Active Lifts, Wheelchair Ramps, and Securement Devices*. This ratio is equivalent to a ramp angle of 7.125 degrees. Figure 10.5 shows the dental cart clearance

over a 7.125 degrees ramp. The height of the platform is five inches, and the height of dental cart clearance over the ramp was calculated as 0.8093 inches.

Maximum deflection of platform: The maximum load that the tilting platform will be subjected to will occur when the dentist's chair and portable cart are loaded on to the platform and the patient is resting in the chair. A total load of 1000 pounds was used in the calculations including a 450-pound dental chair, which is the heaviest of possible chairs, 108 pounds of 0.75-inch thick aluminum used for the portable cart, and a 442-pound person. The aluminum that was used in the platform was 0.5-inch-thick T6061 Aluminum. The calculations assumed simple supports and two symmetrical point loads, 500 lbs. each. The length of the platform was 40 inches, its width was 30 inches, and each point load was 4.5 inches from the corresponding end supporting point. The maximum deflection of the platform was calculated as 0.106 inches.

Initial force required for lifting the platform: The dental platform is supported by a frame made from four by four-inch steel angle bars. Two pair of scissors arms, which are two inch by one half-inch steel bars, support the frame. The frame and platform are

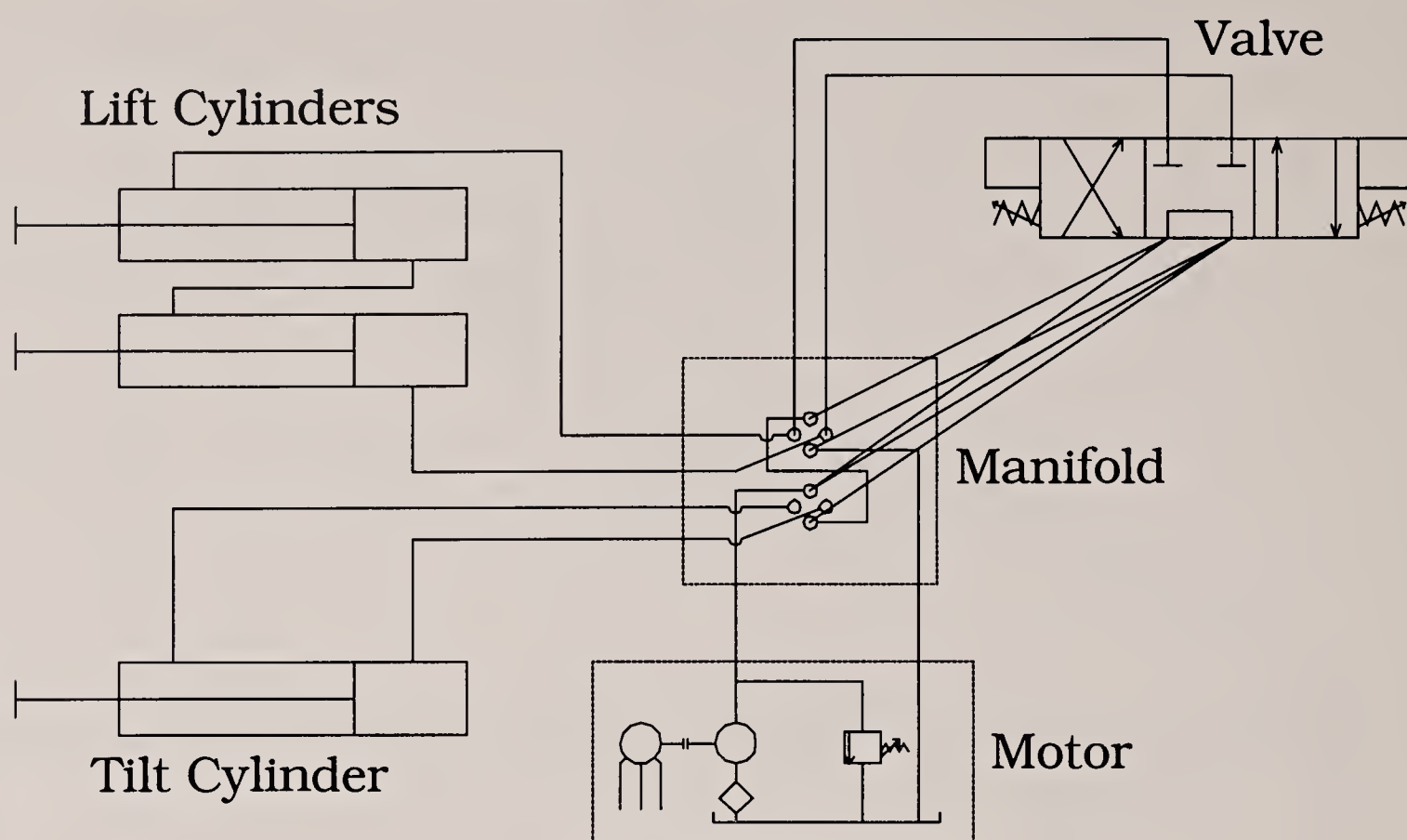


Figure 10.4. Flow Diagram Of The Hydraulic System.

lifted by two hydraulic cylinders, which act on the end of the top frame. The downward force upon the cylinders includes the patient, the wheelchair, the lift platform, and the lift support frame. The initial angle of the hydraulic cylinders is calculated to be three and a half degrees. Seventy percent of the patient's weight will be located on the back wheel while the remaining thirty-percent will be located on the front wheel. The weight of the patient and wheelchair is 472 pounds. The back wheel of the wheelchair is located eight inches from the scissors arm closest to the hinge. The weight of the tilt platform and the steel frame is 72 pounds. The center of the scissors arms, when the platform is down, is located 14 inches from the supported end of the scissors arms. Using the principle of virtual work, the force required from each cylinder to lift the platform was calculated as 9828 pounds. Each cylinder has a maximum operating pressure of 2500 psi and a bore diameter of 2.75 inches, providing thus a force of up to 14849 lbs., which corresponds to a factor of safety of 1.51.

Initial force required to tilt the platform: The dental platform will be tilted by one hydraulic cylinder based close to the hinged end of the platform and extending out to the middle of the platform. The moment calculations for the amount of force needed to

tilt the platform are made around this end. The forces involved in the calculations include two forces that are created by the wheelchair and the patient in the wheelchair. These two forces are located 16 inches apart from each other because this is the average distance between wheels for different types of wheelchairs. It is also assumed that the wheelchair and patient will weigh 400 pounds maximum and that the back wheel will support 70 percent of this weight as the center of gravity of the patient will be located toward the back of the wheelchair. A third force consisting of 72 pounds of platform material acts downward against the hydraulic. This force is considered to act at the center of the 40-inch platform. The hydraulic unit will be acting at an initial angle of no less than 2 degrees from the platform and the force will be located 25.5 inches from the hinged end of the platform. Calculations were performed to determine how the force required and exerted by the hydraulic unit is affected by the angle at which the hydraulic cylinder is acting, and by the distance between the hinge on the platform and the location of the rear wheel of the chair. Distances ranging from 5 to 15 inches and angles from 3.5 to 5.0 degrees were considered. The maximum value of the minimum force required by the hydraulic unit to tilt the platform was calculated as 6012.5 pounds, which corresponded to a distance of

15 inches and an angle of 3.5 degrees. The tilting cylinder has a maximum operating pressure of 2500 psi, a bore diameter of 2.5 inches and an 8- inch stroke, thus providing a force of up to 12272 lbs., which corresponds to a factor of safety of 2.04.

The prototype is presently being evaluated. Rewiring of the electrical system as well as completion of fabrication of the cart and the ramp still must be done before it is to be installed.

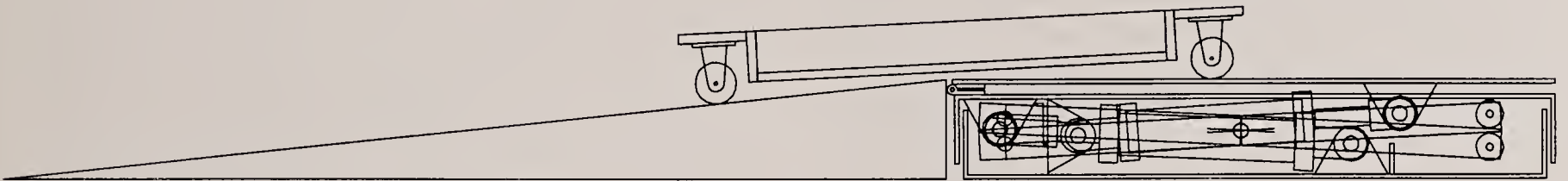


Figure 10.5. Dental Cart Clearance Over Ramp.

Prototype For A Prosthetic Hand

Designers: Richard Colwell, Eric Hardwood, Jorge Tinnirello, Raj Vaishnav

Client Coordinator: Dr. Gregory Nemunaitis, Medical College of Ohio and St. Vincent Mercy Medical Center

Supervising Professor: Dr. Steven Kramer

Department of Mechanical, Industrial & Manufacturing Engineering

The University of Toledo

Toledo, Ohio, 43606

INTRODUCTION

The purpose of this project was to design and build a prototype for a prosthetic hand that would provide a lower-arm amputee with a replacement appendage. The project was limited to the mechanical workings of the hand; the interface of the actuating electrical signals will be developed later by another group of senior design students. The design of the hand centered

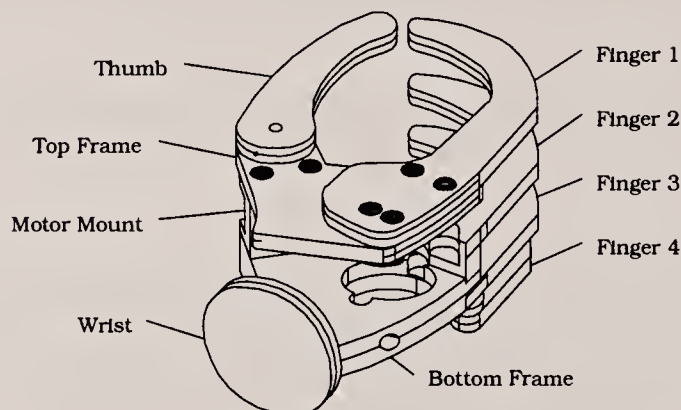


Figure 10.6. Prosthetic Hand in a Pincher Grip Mode.

on functionality and appearance. The prototype consists of an economical mechanical linkage with two degrees of freedom allowing for a pinching grip, a large-radius cylindrical grasp, and a small-radius cylindrical grasp. A model, constructed from wood and controlled by an electric motor, was tested for functionality and appearance. The prototype, shown in Figure 10.6, includes four parts: the thumb and its drive train, and the finger and its sliding drive train. A cosmetic outer covering of the hand was incorporated into the prototype.

SUMMARY OF IMPACT

Lower-arm amputees have a limited number of reasonably priced options for a prosthetic hand. One option is a hand with one degree of freedom, known as a gripper or hook. This is a mechanically actuated device in which the user operates the hook by moving his or her good arm. This device costs about \$360; while is functional, it is not very natural in appearance. The second option is a myoelectrically con-

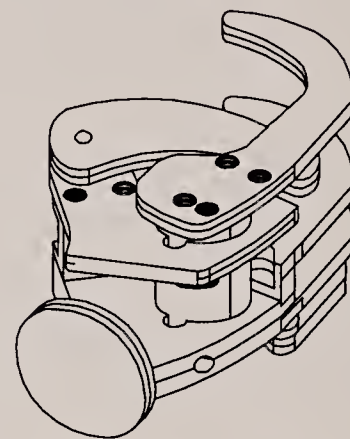


Figure 10.7. Prosthetic Hand When Fully Closed.

trolled pincer-rip prosthetic device. Although this option has a natural appearance, it has limited functionality and costs about \$5,000. The third option is a myoelectric hand with multiple degrees of freedom, which looks natural but costs \$30,000. The goal of the current project was to design a hand that: 1) provides a pinched grip of 20 pounds; 2) carries a transverse load of 50 pounds across the four fingers; and 3) could be marketed and sold for around \$7,000.

TECHNICAL DESCRIPTION

Functionality, weight and appearance were the three primary design criteria. With regard to weight, the prosthetic hand was to be comparable to the weight of a human hand, or possibly less. With regard to appearance, it was decided that the hand should closely resemble a human hand including size, weight and general appearance. Cosmetic glove and inner plastic shell from Otto Bock (a German company) were incorporated in the prototype to cover the prosthetic hand. The cosmetic glove has four fingers and a thumb, and is made to resemble human skin color. It is long enough to fit on a human arm. In the inner shell glove, two fingers are movable and other two are rigid.

The functionality of the hand depends upon degrees of freedom and weight. The prosthetic hand was designed to have three grips using two motions: thumb

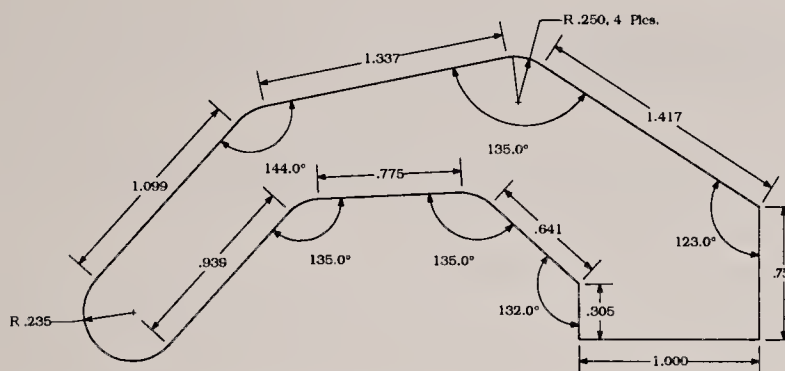


Figure 10.8. Geometrical Details Of A Finger Profile.

rotation and finger translation. The first grip is a pincher grip used to grasp small objects; it involves bringing the fingertip to the thumb tip, as shown in Figure 10.6. The second grip is a large-radius cylindrical grasp; it is accomplished by cupping the fingers and thumb around a larger object, such as a pop can. The third grip is a small-radius cylindrical grip. In humans, this grip is also called a lateral pinch; it is made by cupping the fingers around the object and sliding the thumb along the first finger, as one would do when carrying a suitcase (see Figure 10.7). In the prosthetic hand, the first finger is driven to allow the thumb to pass between the first and second fingers.

The prosthetic hand was designed using IDEAS Master Series 2.1. This software was chosen due to its accessibility, dynamic viewing capabilities, and finite element analysis (FEA) features. The fingers and thumb profiles shown in Figures 10.8 and 10.9 were derived from direct observation. The fingers were shaped to have a matching internal curvature, to facilitate the grips and to distribute the loads; however, external curvatures and tips were shaped variably for a more realistic cosmetic appearance. Using IDEAS, it was found that the largest stresses occurred along the internal curve.

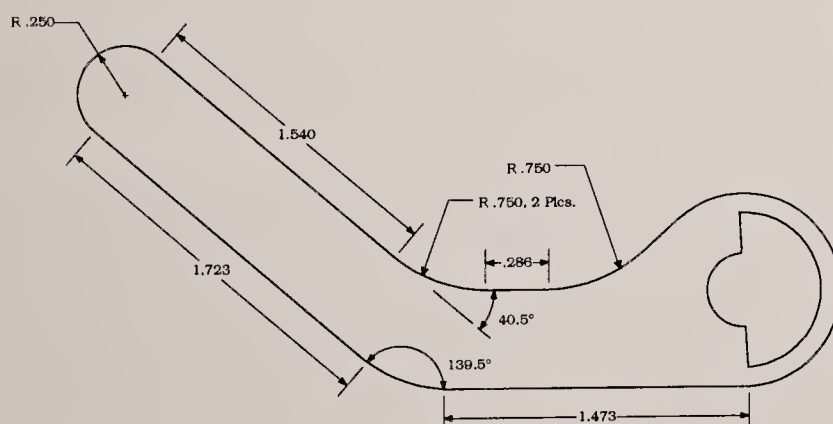


Figure 10.9. Geometrical Details Of Thumb.

The main drivetrain of the prosthetic hand drives the thumb, which does the work of the hand by opening and closing to accommodate the various grips. The motor and drivetrain were obtained as a set. However, bevel gears were used to accommodate the orientation of the motor and drivetrain. In order to accomplish the design objective of a grip force of 20 pounds, the drivetrain would have to be custom made. However, due to financial constraints, a smaller gearbox that was able to provide a grip force of only one pound was selected. The sliding finger drivetrain generates a translation motion, requiring no resistance to a load beyond its own inertia force. Since it is an all-or-nothing motion, no middle stops were needed, and a push solenoid is used to drive the finger. The frame was designed to hold these parts together and connect the hand to the prosthetic attachment via the wrist. The frame was designed to withstand the forces of the hand and to provide much of its shape. After the hand was designed in IDEAS as a solid model, a FEA was undertaken to show that the design could withstand the forces applied to it. The model has two different load cases: 1) a pinched grip with 20 pounds of force between the first finger and thumb tip; and 2) a 50-pound transverse force across the four fingers for load support. Thin shell elements, beam elements, and three-dimensional brick elements were employed in the analysis.

While the fingers and frame of the final prototype are to be made of aluminum, a first prototype made of wood and powered by an electric motor was constructed to simulate the mechanical motion of the hand. The objectives met include design for strength, weight and appearance. Concerning functionality, the thumb drive train used did not provide adequate pinched grip force. Incorporating a planetary gear drive or other suitable mechanism may rectify this. It is anticipated that the goal of a \$7,000 price tag could be readily achieved in reasonable production quantities.

Based on a peer review, this work has been chosen as one of the winners of the 1996 Young Design Engineer's Paper Competition from the American Society of Mechanical Engineers (ASME). The paper was presented at the ASME International Congress held in Atlanta in November, 1996, and received a prize of \$500, plus a certificate. This project was one of four projects in the United States to be recognized with this award for 1996.

Rearward Viewing Device

Designers: Kurt Starkey, Bruce Tremmel, Hsu-Chen Chiu, Kuan Kooi

Client Coordinator: Dr. Gregory Nemunaitis, Medical College of Ohio and St. Vincent Mercy Medical Center

Supervising Professor: Dr. Richard Irey and Dr. Steven Kramer

Department of Mechanical, Industrial & Manufacturing Engineering

The University of Toledo

Toledo, Ohio, 43606

INTRODUCTION

The purpose of this project is to design and build some type of rearward viewing device for a patient who is confined to a wheelchair and head and neck brace due to a neck injury. This patient used a halo-brace system to immobilize his neck and head to prevent further injury. He was not able to see around himself since his neck is immobilized in the system. Figure 10.9 shows the prototype and Figure 10.10 shows the patient using it.

SUMMARY OF IMPACT

The rearward viewing device was developed to enable a stationary person with an immobilized neck to see side to side, down, and behind without moving his head or wheelchair. Immobilized patients often feel uncomfortable when another person is present but cannot be seen. Since such patients often have full movement of their hands and arms, the device was designed to be controlled by the hands. Adjustability was a primary consideration. The prototype was designed for people of all sizes. The only other such device on the market is a pair of prism glasses, with two critical limitations: 1) it merely allows the patient to

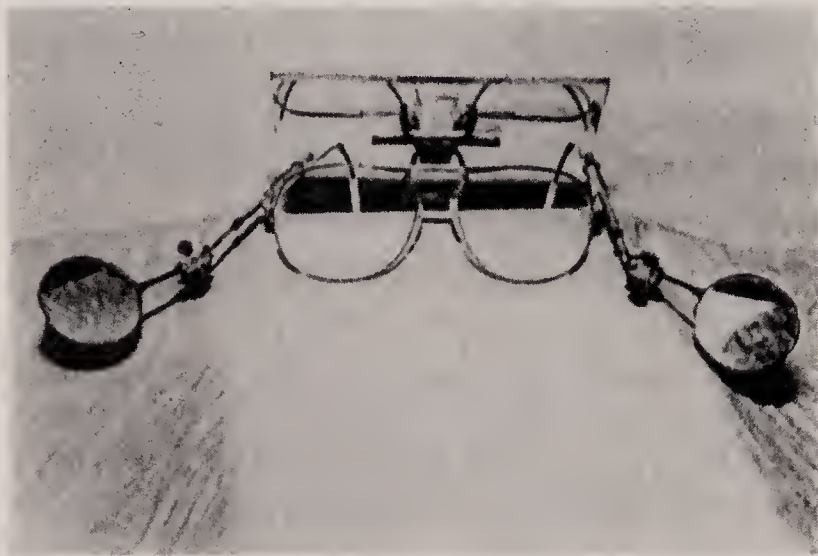


Figure 10.9 Front View of the Rearward Viewing Device for Non Prescription Glasses



Figure 10.10. The Patient Using The Prototype While Wearing The Halo Device.

view the frontal area; and 2) it is weighty, hurting patients' noses if worn for long periods.

TECHNICAL DESCRIPTION

Immobilization of the head and neck is often required for a limited time, averaging about six months; thus, cost should be low to take into account its limited period of use. Other design criteria include: 1) allowance for the patient to see side to side, down, and behind without moving his head or wheelchair; 2) weight as light as possible; 3) ability to be attached to a pair of prescription glasses; and 4) adjustability, such that it could be used by a variety of people.

The device combines mirrors, a telescoping tube, and glasses, to enable the patient to see in all directions. It was designed for a patient who wears prescription glasses, but may be used by patients who do not. The device includes two telescoping arms that are connected with a metal wire and monofilament line wound around the glasses and arms.

Each arm carries a convex mirror that allows the patient to see behind himself, and a flat circular mirror

(glued to the convex mirror with a hot glue from a glue gun) that allows to see in front. Additionally, a rectangular flat mirror allows the patient to see downward. This flat mirror is clipped to the central upper portion of the frame of his prescription glasses.

The telescoping arms are antennae that were cut to length and drilled to receive a spring-loaded holding clip. An aluminum slug was then used to cap the cut-off end of each antenna to prevent dirt from collecting and to protect the ends.

The ball portion of a flexible ball joint was obtained from a telescoping inspection mirror, and the socket was welded onto the end of the antenna. The flexible joint grip plates from the inspection mirror were modified by drilling a larger hole in them to accommodate a thumbscrew that was used for tightening the ball joint. One of the ball joint grip plates had a nut welded to it to provide threads for the thumbscrew. The ball arm portion of the inspection mirror was altered to receive the convex and flat mirrors for looking in the rearward direction. The ball arm was crushed into the form of a spade to provide a flat surface on which to glue the mirror.

The convex and flat mirrors had to be cut to size. The convex mirrors were cut by turning them on a lathe. The mirrors were wedged between rubber and paper in a wood chuck in order to prevent the metal backing from scratching off the mirrors. The flat and convex

mirrors were then attached to the device by sandwiching the spade between the two mirrors and gluing them together. The telescoping arms were connected to the glasses with a metal wire and monofilament line wound around the glasses. This is considerably stronger than a spot weld would have been; the device is not likely to break if it is dropped.

It was verified that the convex mirrors allowed the patient to see a person who is standing six feet behind him and 16 feet to his right or left. The patient can see anything that is more than a foot away from his head, thus delimiting thus the blind area for the device. Figure 10.11 illustrates the rearward viewing area for the device using the convex mirrors. Figure 10.12 shows the frontal viewing area using the flat mirrors.

The material cost to build the prototype for the patient who wears prescription glasses was \$35.00. For the patient who does not wear prescription glasses, an additional \$10.00 is required to purchase wire frame glasses.

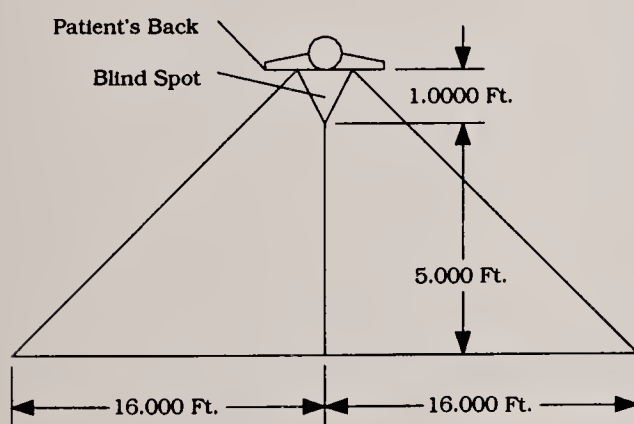


Figure 10.11. Rearward Viewing Area With Convex Mirrors.

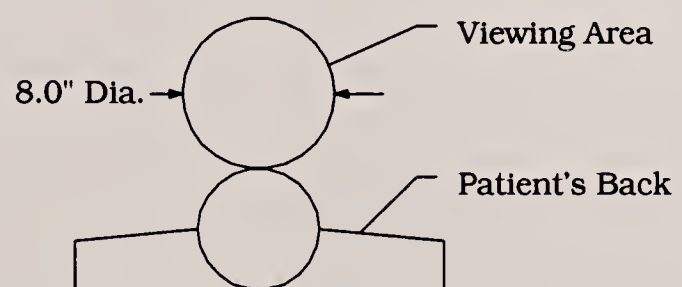


Figure 10.12. Frontal Viewing Area With Flat Mirrors.

Wheelchair Lift For Independent Home Access

Designers: Yakoob Abdulwahid, Sung Un Choi, Kasey Lewis, Tricia Thornell, Jenny Wiles, Brad Thomas

Client Coordinator: John Malloy, Physical Therapist, PT Services

Supervising Professor: Dr. Richard Irey

Department of Mechanical, Industrial & Manufacturing Engineering

The University of Toledo

Toledo, Ohio, 43606

INTRODUCTION

The objective of this project was to design, build and install a lift that allows a woman with double amputation of the legs to enter and exit her home in a wheelchair, without the assistance of another person. The basic principle of the design is that of a forklift. A hydraulic cylinder pushes up on two chains that are connected to both a fixed point and a platform. This allows the platform to move twice as far as the cylinder head. The moment created by the platform is absorbed by guide rails that are attached to it and to the frame of the lift. The wheelchair lift is located beside the client's front porch.

SUMMARY OF IMPACT

A physical therapist referred the client, who had both of her legs amputated due to complications associated with diabetes. Her left leg was amputated at the knee while her other leg was amputated approximately halfway between the knee and hip. She is learning to use a prosthesis on her left leg; however, this does not give her enough mobility to enter and/or exit her house. A wheelchair lift was designed, built and in-

stalled at the client's home, allowing her independent access in and out of the house.

TECHNICAL DESCRIPTION

The primary design criteria were that the lift: 1) safely lift the client from the ground to the level of her porch; 2) be operable in any weather, as it will be located outside; and 3) have a long life expectancy with either no or low maintenance requirements. The design concept was to use the same basic principle that a forklift uses, as illustrated in Figure 10.13. The basic design involves a cylinder with idler sprockets on the head, extending 10 inches. Two chains were attached to the frame and also to the platform, causing the platform to move 20 inches. A guide rail system was designed to absorb the moment produced by this style of lift. Attached to the platform are two support arms with cam followers. The frame has two 3 by 1.25-inch steel beams that act as guides. The rest of the frame is composed of 1 by 1-inch steel tubes. A plastic plate covers the frame to protect it in bad weather. To keep the platform from rusting, all metal was coated with

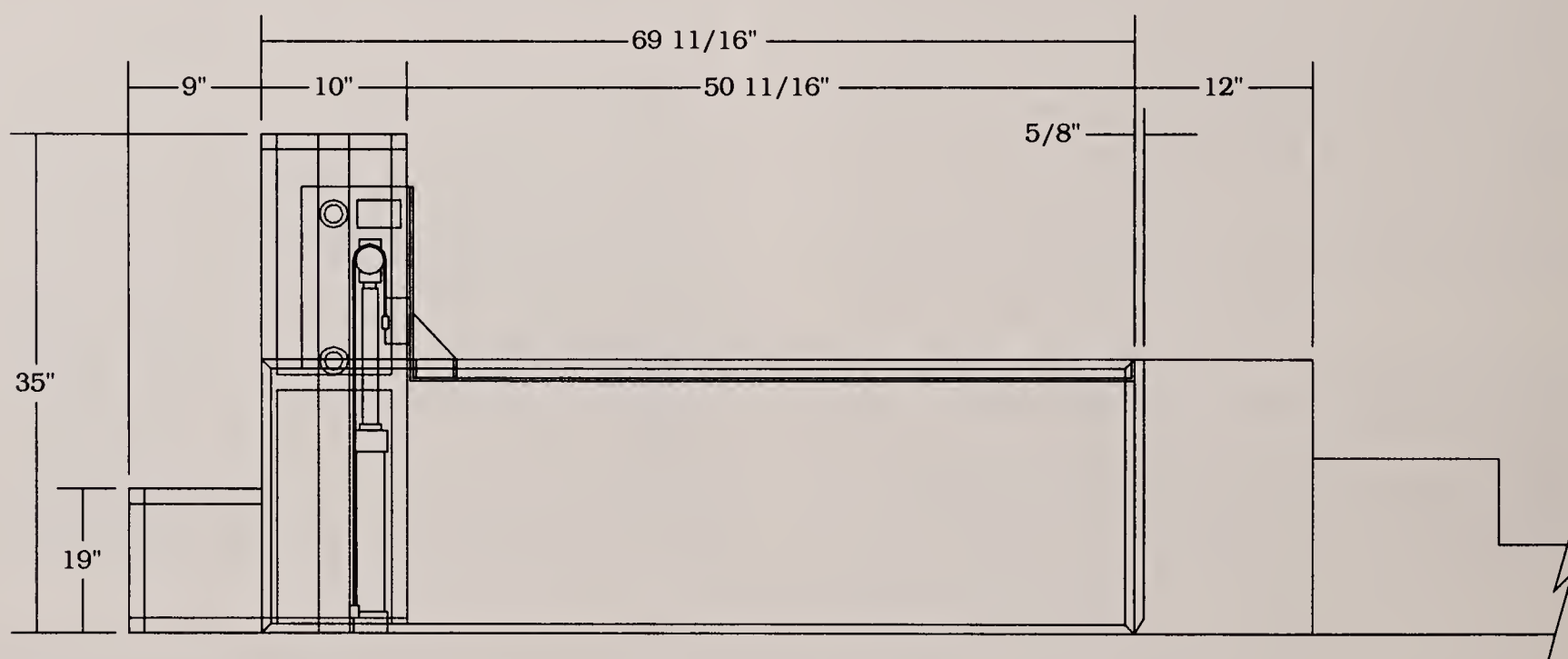


Figure 10.13. Design Concept for the Wheelchair Lift.

primer and then painted.

Four major points of concern were identified in the design. The first is that the platform must not yield or deflect very much. The second is that the connection between the platform and the supporting arms be made with complete welds and with 45 degrees corner gussets, such that it is able to withstand the moment load combined with the shear force of the design load applied at the extreme edge of the platform. The third was that the shaft go through the cylinder head and hold the idler sprockets while not yielding or deflecting to any great extent, still remaining narrow enough to fit both the cylinder rod eye and the idler sprockets on both sides. The last major point of concern is that the guide rails, 3 by 1.25-inch steel beams on the frame, be strong enough to withstand the force caused by the cam followers.

The control system for the lift is composed of three parts. The first part consists of three separate boxes that house the temporary contact switches. These switches are designated as up, stop and down. The switch box is then connected to the terminal box that houses two four-pole double-throw relays. These relays are the primary component in the control system and act as a switching mechanism. The third compo-

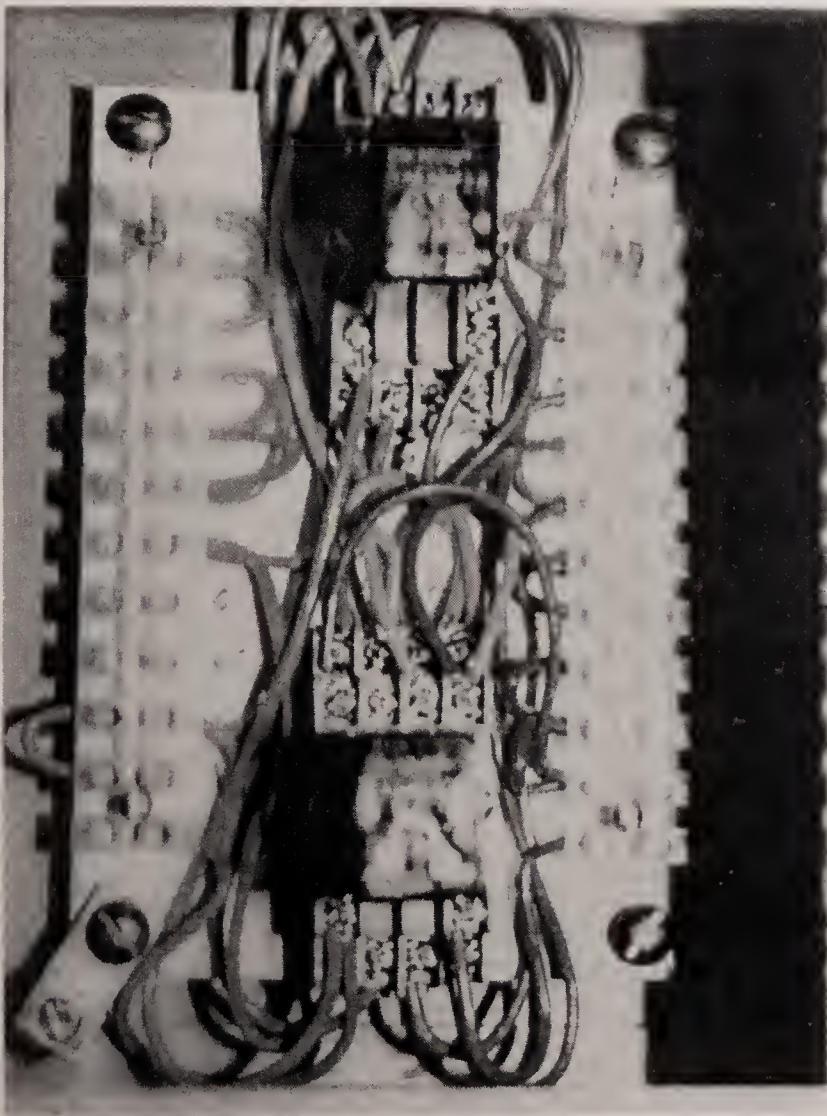


Figure 10.14. Control Box

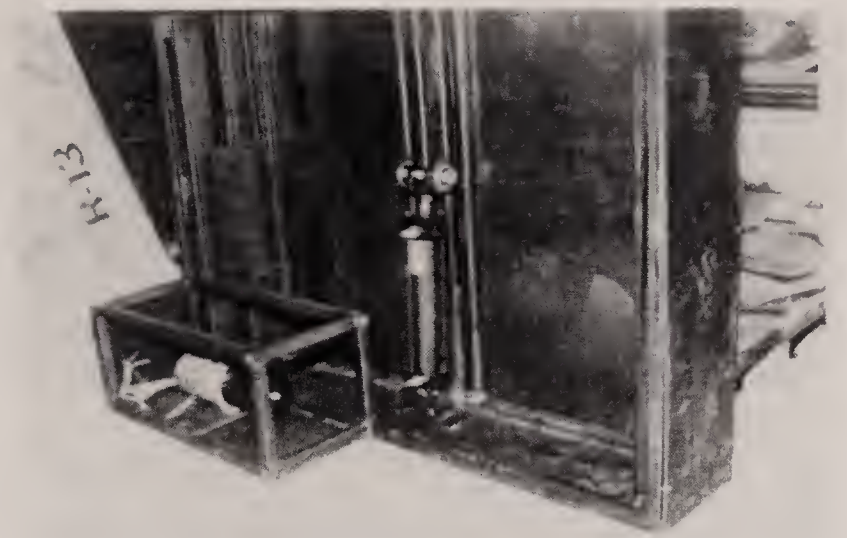


Figure 10.15. Frame Assembly Housing the Motor and the Cylinder.

nent is the limit switches. These switches are mounted to the frame and indicate to the control system when the lift is completely up or down. The limit switches are also connected to the terminal box. Originally, connection of the relays to solenoid valves on the hydraulic system was considered; however, solenoid valves were not used in the final design. It was decided that a reversible pump/motor system would be used to provide the correct flow rate, thus, eliminating the need for the solenoid valves. With the relays directly connected to the motor, the relays trigger the pump to let fluid lower or raise the cylinder. The other connections of the relays to the motor allow for the automatic start and stop of the system in conjunction with the limit switches. The control box is shown in Figure 10.14. Figure 10.15 shows the frame assembly housing the motor, the cylinder and its connection assembly

Because the design was kept simple, the wheelchair lift was relatively easy to manufacture. The platform, support arms, and most of the frame were made of 1020 steel. The first thing that was constructed was the frame to house the cylinder and pump, along with the platform itself. The frame was then painted to prevent any rust from occurring. At the same time, a six-inch concrete slab that serves as a foundation for the lift was poured at the client's residence. The motor/pump assembly and the cylinder were then mounted to the frame. The plastic sheet stock was cut to fit the dimensions of the frame. Once the front plastic sheets were installed, the platform was connected to the frame by connecting the cam followers to the guidepost on the frame and connecting the chains over the sprockets. The hydraulic cylinder was then connected to the pump and the control system installed. The remaining exposed frame was covered

with the plastic sheets. To ensure safety, a railing was used on the lift's platform to box in the area that will be used to transport the client. Side arms were utilized as another safety precaution. These side arms provide not only extra support against the moment of the system, but also a barrier so that nothing can get under the platform. With the lift fully operational and tested, the entire system was transported to the site and installed by bolting the frame into the concrete.

The total cost of the system was a \$1,600, all of which was donated by a charitable organization. This cost is far less than the price of \$10,000 to \$15,000 quoted for building a ramp to the client's house.

CHAPTER 11

UTAH STATE UNIVERSITY

College of Education
Center for Persons with Disabilities
Logan, Utah

Principal Investigators:

Frank Redd, Ph.D. (801) 797-1981

redd@cc.usu.edu

Marvin G. Fifield, Ph.D. (801) 797-1981

Short-Range Autonomous Wheelchair Controller

Design Team: Steven J. Smith

Client Coordinators: Dr. Richard Baer, Center for Persons with Disabilities

Dr. Marvin Fifield, Center for Persons with Disabilities

Supervising Professors: Dr. Robert W. Gunderson, Center for Self Organizing and Intelligence Systems, Department of Electrical Engineering

Dr. Frank Redd, Department of Mechanical and Aerospace Engineering

Utah State University

Logan, UT 84322

INTRODUCTION

Most power wheelchair users can safely and accurately control their chairs in most situations. With practice, control devices, including joysticks, sip-and-puff straws, and mouthsticks are effective input devices for wheelchair control. However, a variety of environmental barriers, such as poorly designed bathroom stalls, restrictive office cubicle areas, narrow doorways, and uneven terrain, present difficulties that are further compounded by inexperience and/or specific disabilities of the user.

In focus group discussions with power chair users, a need repeatedly expressed was for an autonomous system that would take control of the wheelchair until a difficult obstacle(s) is avoided.

To address this need, the Center for Self-Organizing and Intelligence Systems (CSOIS) engaged in an investigation of the application of virtual reality and associated technologies as a means of assisting consumers to steer and control power wheelchairs. During the past two years, several solutions have been investigated and projects to design and fabricate prototypes have been undertaken. Engineering students and consumers have collaborated individually and as team members in the investigation of fabrication and field testing of various autonomous power chair controllers.

SUMMARY OF IMPACT

This short-range, autonomous wheelchair controller is designed to allow a power chair user to safely and quickly navigate in difficult situations. It is activated by simple on/off and desired-direction command input into the existing interface (joystick, mouthstick, sip-and-puff straw). The system can be engaged and disengaged instantaneously. Once engaged, it will map the immediate environment using sonar image

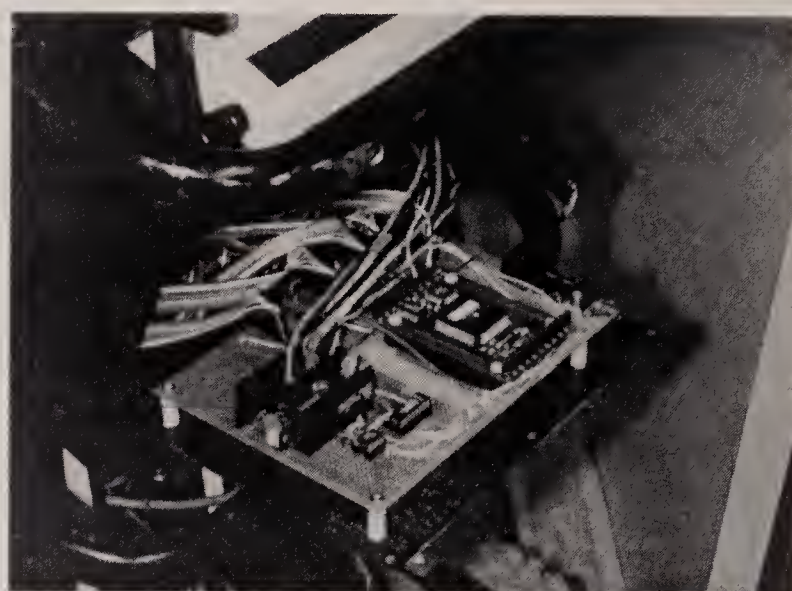


Figure 11.1. Wheelchair Control System.

data and plot a course in the direction indicated by the user. While moving toward the desired direction under autonomous control, the user can regain manual control at any time.

TECHNICAL DESCRIPTION

For short-range autonomous power chair control, an obstacle-detection/obstacle-avoidance system is implemented using sonar for range detection and image data from a laser/CCD camera for obstacle identification. Input from these components is used to construct a path plan control file. An onboard computer system uses this file to guide the wheelchair from the point of activation to the desired destination. Optical encoders on the two rear wheels, and a digital compass mounted near the center of gravity of the chair, provide positional feedback and minimize error. The interface between the computer and the chair consists of the existing control device (i.e., joystick, mouthstick, or sip-and-puff straw). Figure 11.1 provides a systems block diagram of the wheelchair control system on board. Figure 11.2 provides a diagram of the remote power chair control system.

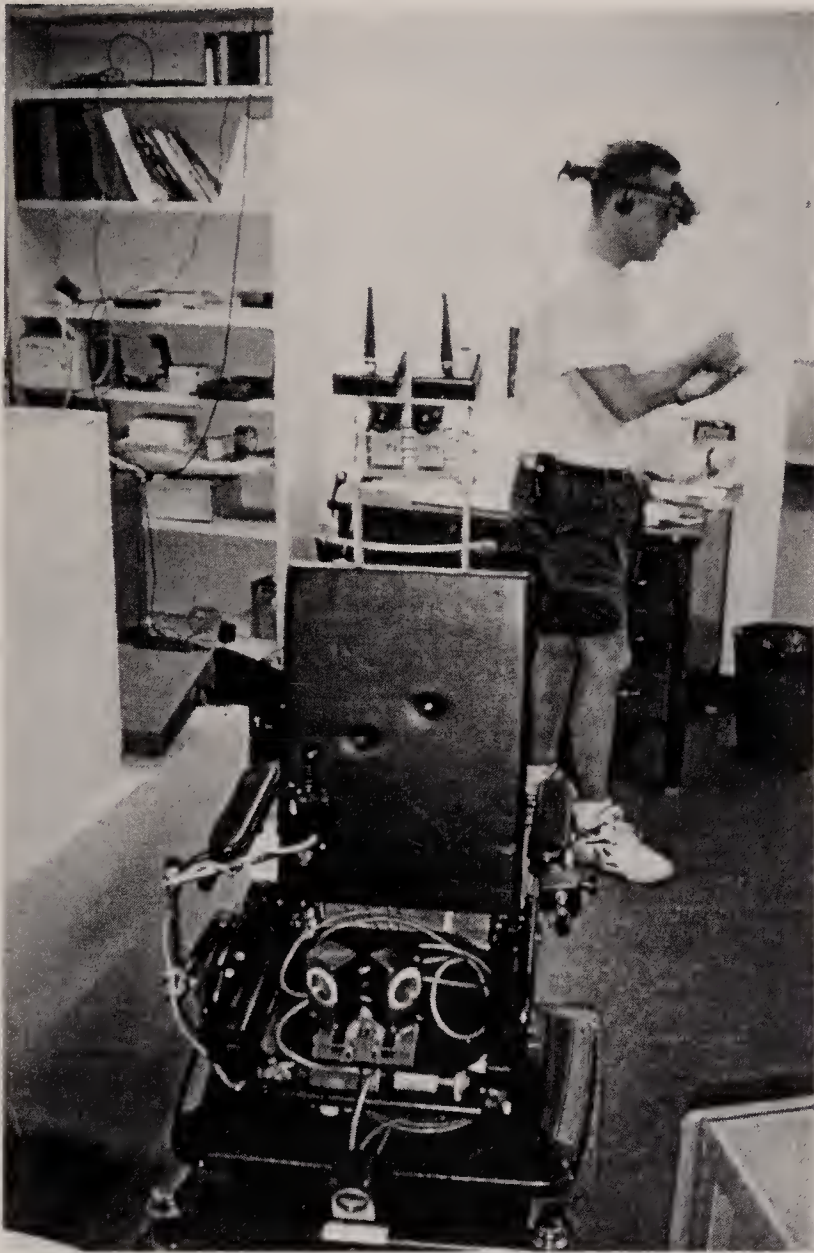


Figure 11.2. Short-Range Autonomous Wheelchair.

Feasibility

A prototype of the short-range, autonomous wheelchair controller was developed and tested. The need was identified for a more sophisticated on-board processor to provide additional speed and reliability.

The Tattletale 8 was designed to provide security and fault protection when control is taken from the user for a period of time. In addition, a sonar location system was added for obstacle detection. The primary purpose of this project was to integrate these elements into a system and implement the autonomous system in software.

The cost of equipment and materials for this project include the following:

ITEM	QUANTITY	TOTAL COST
Laser Suite--Lasiris ULG-519	1	\$995
Digital Compass--PCITCM2	1	\$795
Sonar Kit--Polaroid OEM Kit	1	\$99
Total Cost		\$1,889

Autonomous Wheelchair Positioning Feedback System

Designer: Collin Lewis

Client Coordinators: Dr. Richard Baer and Dr. Marvin Fifield, Center for Persons with Disabilities

Supervising Professors: Dr. Robert W. Gunderson, Center for Self Organizing and Intelligence Systems

Department of Electrical Engineering

Utah State University

Logan, UT 84322

INTRODUCTION

Students at the Center for Self-Organizing Intelligent Systems (CSOIS) at Utah State University have been working on a number of projects to make powered wheelchairs more functional and consumer friendly. CSOIS currently has a functional power chair that can be remotely operated by virtual presence control. Future plans include constructing a "virtual" map of buildings, using construction blueprints, and then using that map to program the power chair to navigate to any destination in the building on command, following the most efficient route. A prerequisite to accomplishing this is for the autonomous power chair to know its own location. The purpose of this project was to provide a means of sensing the movement of the chair and to deliver that information to participants in other phases of the project in efforts to complete the information loop and allow the chair to drive itself.

SUMMARY OF IMPACT

Many users of power chairs lack the capacity to adequately control the guidance system on their own in an efficient manner that will facilitate independence and not damage the chair or the environment in which it operates. An autonomous power chair that can travel to remote locations upon command, circumvent obstacles, and provide additional safety, will be of tremendous benefit to those consumers who have not been able to operate control systems independently. An essential component of an autonomous power chair is a system whereby positional feedback is provided.

TECHNICAL DESCRIPTION

The drive system of the autonomous power chair consists of a motor running through gear reductions to drive each of the rear wheels. The front wheels are castor style. Thus, steering is accomplished by driving one of the rear motors faster than the other.

Driving straight requires both motors drive at the same speed. Each drive motor has an auxiliary shaft to which a wheel of an operating encoder was attached. The encoder was attached to the housing of the drive motor; it contains an infrared emitter detector that counts the slots in the encoder wheel as it rotates with the armature of the drive motor. The output of these sensors is a digital signal that is fed into a processor that counts the pulses and determines distance and direction traveled by the chair. A Hewlett Packard Model #HEDS-6310 encoder assembly was fit into the motor housing; it generates 500 pulses per revolution of the drive motor. The Onset Computer Corp. (Pocasset, MA) makes an embedded system called the Tattletale Model 8, which is equipped with the I/O lines to efficiently monitor the signals from each wheel and process the data. This will obtain positional feedback from the wheels of the power chair and represents the first step in an intelligence control system. This project lays the foundation for other projects that will enhance the independence of people using power chairs.

The hardware required to implement the positional feedback system includes:

ITEM	QUANTITY	TOTAL COST
Encoders HP #HEDS-6310	2	\$131
Onset TT8 Processor	1	\$500
Other costs: wiring, ma- chining, miscellaneous hardware		\$250
Total Cost		\$1,281

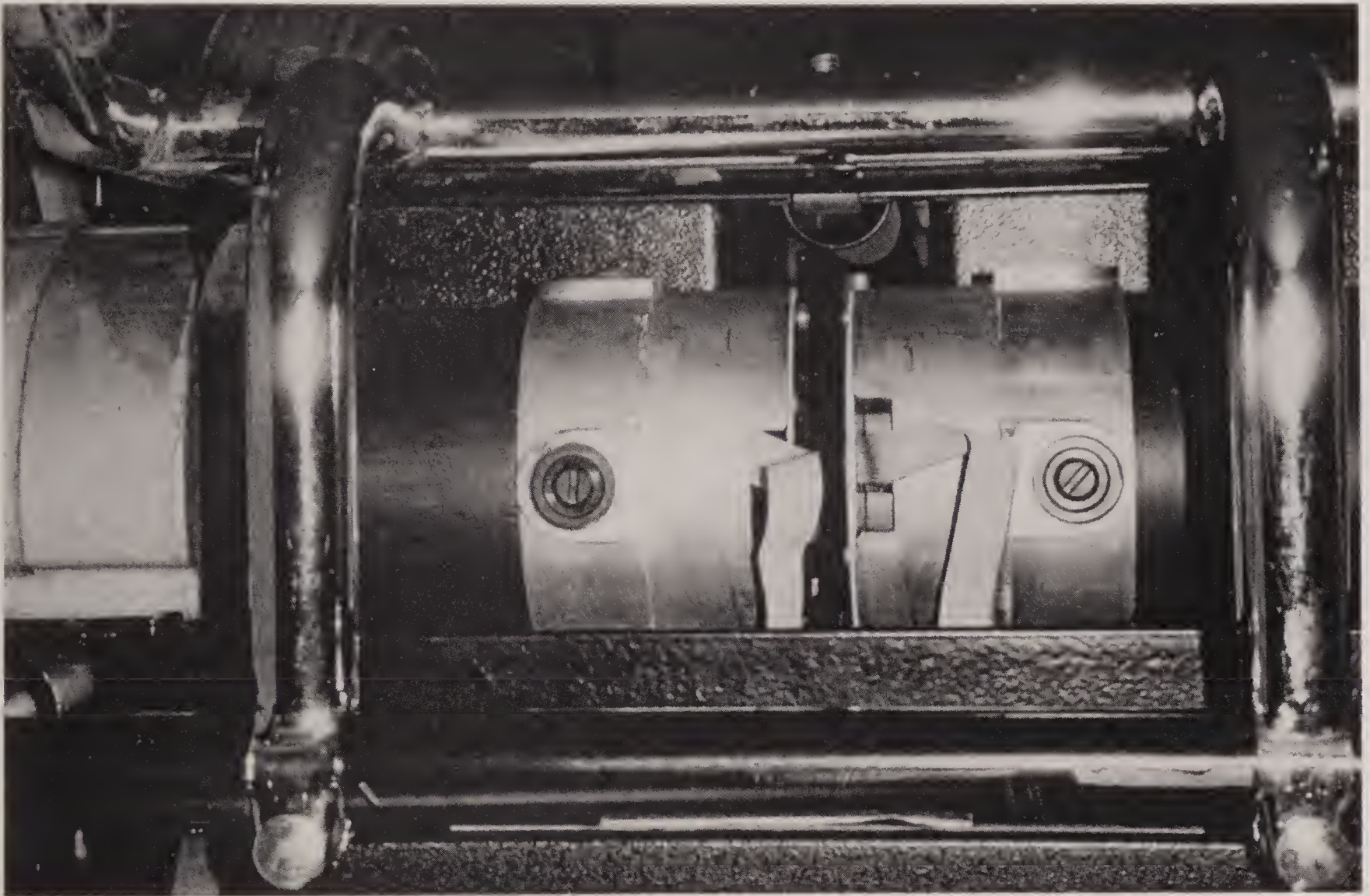


Figure 11.3. Photograph of the Autonomous Wheelchair Positioning Feedback System.

Path Navigation Program for a Power Wheelchair

Designer: Monica Joshi

*Client Coordinators: Dr. Marvin Fifield and
Dr. Richard Baer, Center for Persons with Disabilities*

Supervising Professor: Dr. Ben Abbott

Department of Computer Engineering

Utah State University

Logan, UT 84322

INTRODUCTION

An essential characteristic of an autonomous power chair includes its ability to navigate a pre-determined path. This project constitutes one component of the efforts of the Center for Self-Organizing Intelligent Systems (CSOIS) at Utah State University to develop innovative approaches in the control of power chairs for persons with disabilities utilizing a "test bed" vehicle. The aim of this project was to develop a program using AutoCAD to prompt the user to draw a path. The program provides information about the path. Traced on the map, this information is then used to remotely navigate the power chair. The program will enable the power chair to follow the path drawn on the map, and to generate the coordinates of the path and other information needed for navigation.

SUMMARY OF IMPACT

Successful path navigation for a power chair will provide a variety of benefits to power chair users. Such a program will: 1) permit the user to travel from one location to another without assistance of another person; 2) prevent the chair from bumping into obstacles, thus, protecting both the environment and the chair; and 3) aid in training the user to successfully utilize manual control systems. As path navigation becomes more sophisticated and as such designs are implemented in conjunction with other sensory systems, paths of increasing length and complexity will be

made possible. Also, safety will increase and user fatigue will be reduced.

TECHNICAL DESCRIPTION

The product was an AutoCAD program designed: 1) to prompt the user to draw the path the power chair would traverse on the map; and then 2) to allow the user to remotely navigate the power chair. Maps of the entire Utah State University campus were loaded into AutoCAD. A utility was developed to prompt the user to draw the path and then traverse it. The components include a "test bed" vehicle developed by CSOIS. The "test bed" vehicle is designed to be remotely controlled. The CAD/CAM component permits the mapping and storage of information on desired paths to be followed and generates the coordinates of the path and other information needed to navigate the power chair.

Proper attention to safety and interaction with other sensory systems of the "test bed" vehicle were accommodated through field-testing and systematic improvement in the program and the interfacing of the components.

In addition to the utilization of the "test bed" vehicle, the cost of materials included AutoCAD software costing approximately \$1,200.

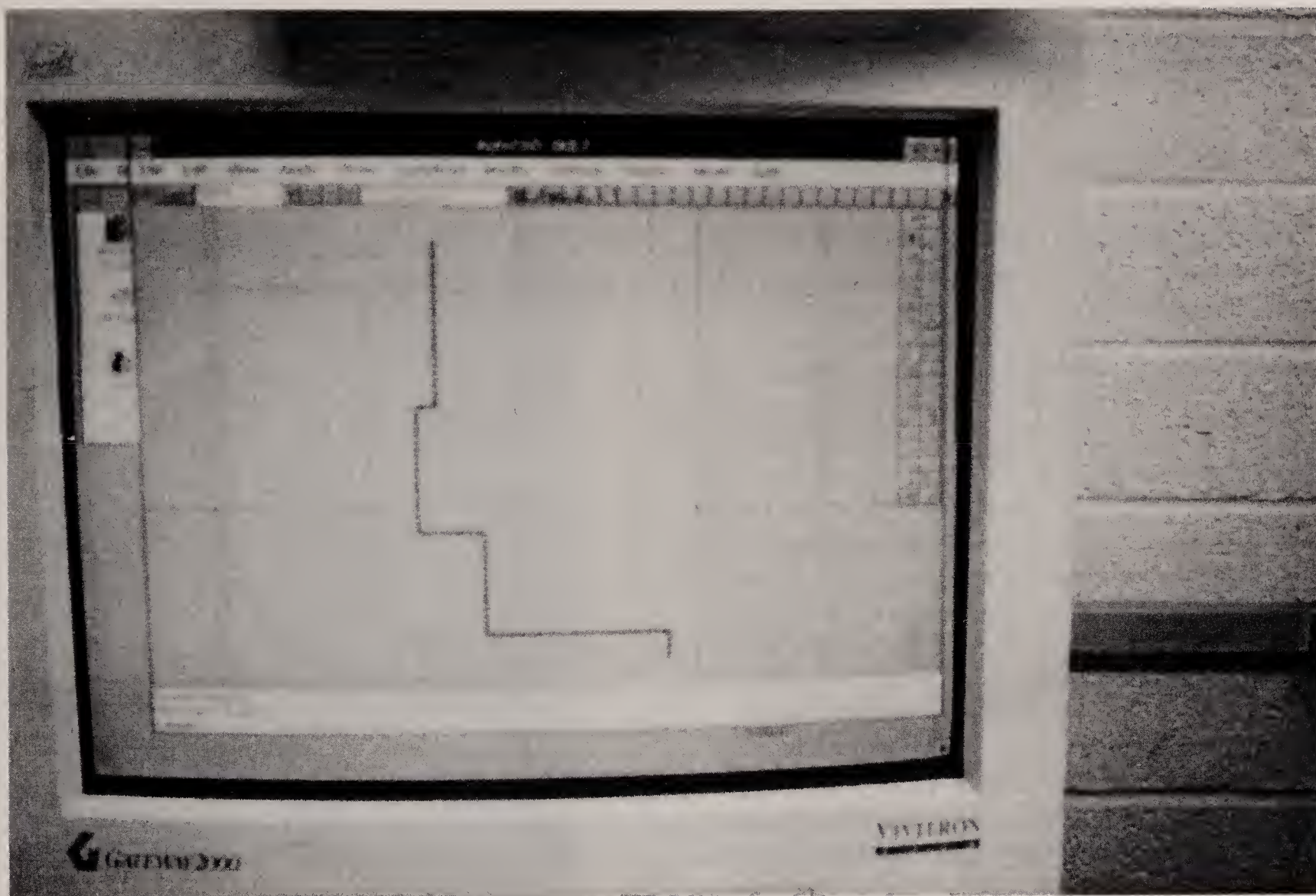


Figure 11.4. Path Navigation Program for Power Chair.

Autonomous Wheelchair Tracking System

Designer: Eric Poulson

Client Coordinators: Dr. Marvin Fifield, Dr. Richard Baer, Center for Persons with Disabilities

Supervising Professors: Dr. Robert W. Gunderson, Center for Self Organizing Intelligent Systems, Department of Electrical Engineering

Utah State University

Logan, UT 84322

INTRODUCTION

To navigate around known obstacles, such as walls and furniture, and to arrive at a specific location, a functional autonomous wheelchair must have information about its position. Typically, when a command is sent to the drive system to move ahead or turn, the control system assumes these commands reflect exactly the new position and orientation of the vehicle. In real life, wheels slip as the chair starts, moves, and stops; this slippage must be accounted for. The autonomous wheelchair tracking system will allow a control system to use information about the rotation of the wheels and the force applied to the wheels to estimate the amount of slippage and to arrive at a better estimate of the new vehicle position.

SUMMARY OF IMPACT

The product consists of a program that collects data from seven controlled computer modules recording information on wheel position, velocity, drive current, and force. When used with a wheelchair (or, in the future, with a scooter or other motorized personal vehicle) it will provide a much improved guidance system that can move people with disabilities autonomously to specific locations. The system will better avoid obstacles, be able to navigate in more confined spaces, and arrive closer to desired positions.

TECHNICAL DESCRIPTION

The sensors, computer modules, and program for this project are designed to work on a "test bed" vehicle. The modules use and record information on wheel position, velocity, drive current, and force.

The relative velocity between a wheel and the surface on which it rests is a function of many parameters. The composition of the surface has a significant effect on slippage, which is sensitive to the force or torque applied to the wheels and the velocity. This project will develop means to estimate that slippage without knowledge of the surface composition. It will incor-

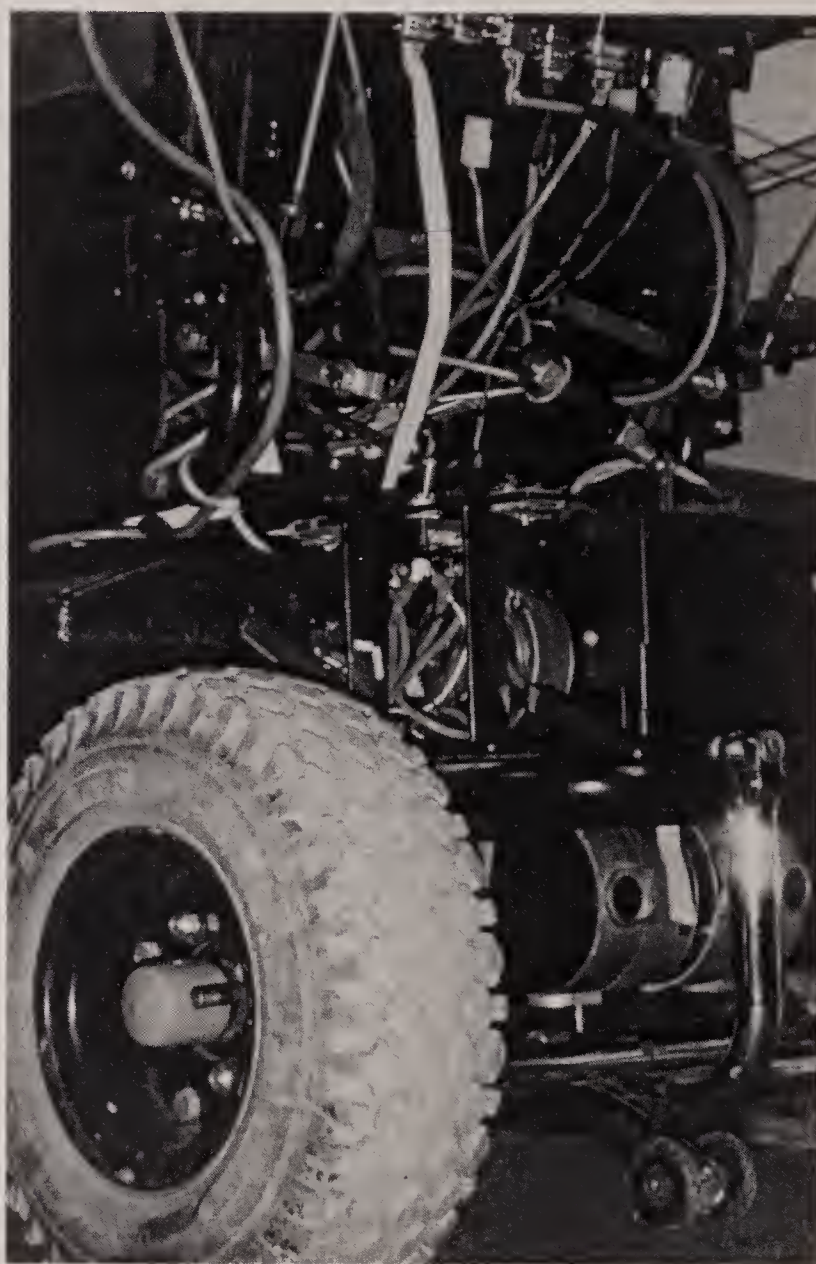


Figure 11.5. Photograph of the Autonomous Wheelchair Tracking System.

porate information about the position of the wheel, the torque applied to the wheel, and how these values change with time. Slippage estimates can then be improved by comparing information from all the wheels on a vehicle.

Feasibility

This project is one part of an ongoing development of autonomous wheelchairs and other vehicles by the Center for Self-Organizing Intelligent Systems

(CSOIS). A "test bed" vehicle for the development of the control algorithms is available. The seven computers used to record information on wheel position are provided by the CSOIS. Thus, support and commitment to the project was available.

Estimated costs of materials include seven control computers at \$500 each, plus the cost of the "test bed" vehicle, and labor for connecting, programming, and field testing the program.

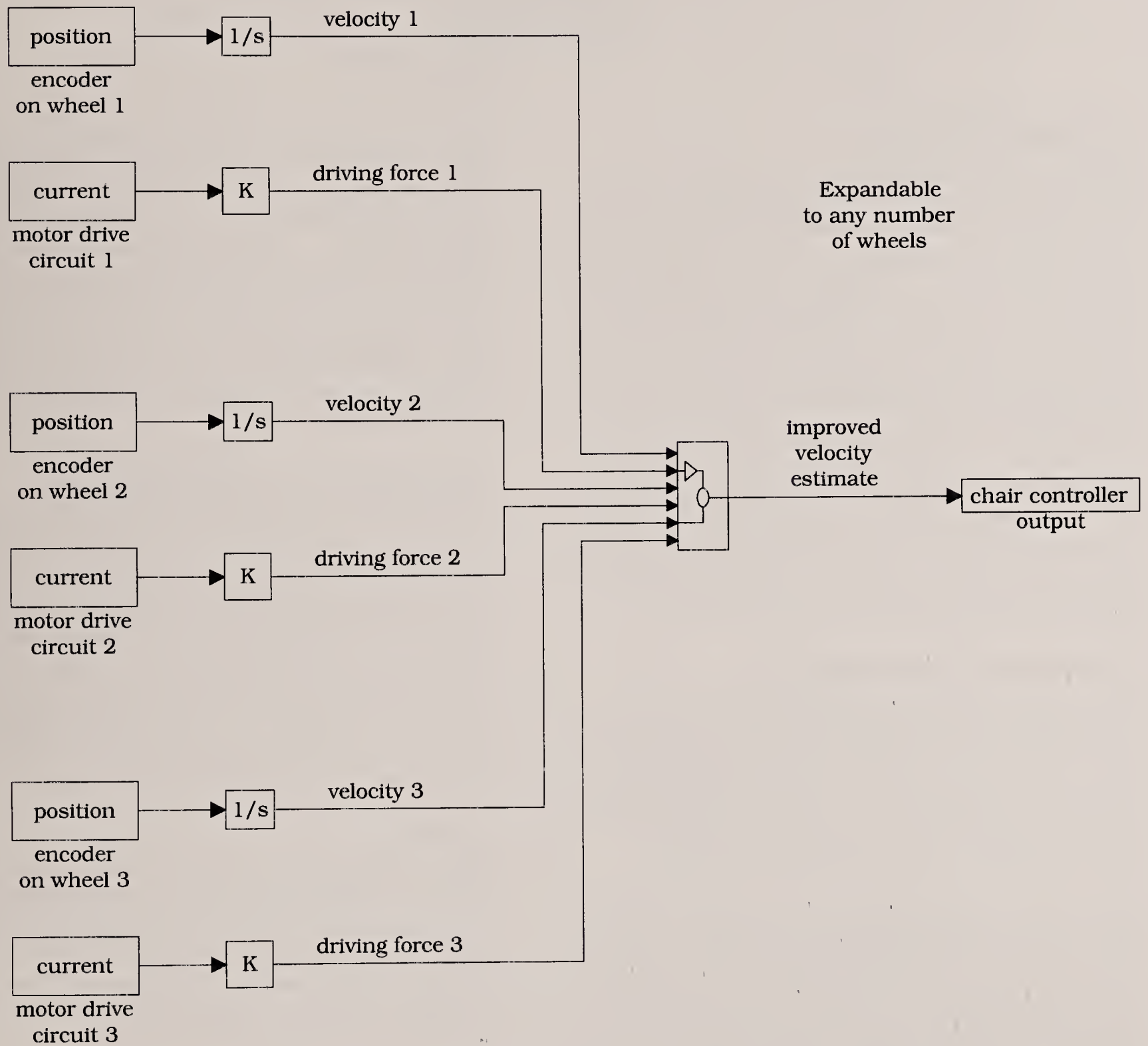


Figure 11.6. Control System Design.

Virtual Reality Representation of Autonomous Wheelchair Training

Designer: Yan Lin

Client Coordinators: Dr. Marvin Fifield, Dr. Richard Baer, Center for Persons with Disabilities

*Supervising Professors: Dr. Robert W. Gunderson, Center for Self Organizing and Intelligence Systems, Department of Electrical Engineering
Utah State University
Logan, UT 84322*

INTRODUCTION

Users of power wheelchairs have repeatedly identified the need for more sophisticated guidance, training, and sensory systems to facilitate movement in the environment and avoidance of many barriers common in the house or workplace. The purpose of the project was to develop a wheelchair capable of sensing and mapping its immediate environment, making navigational decisions based on this mapping, and then taking full or partial control of the chair to help the user move to desired locations in a safe and effective manner. A teleoperable test-bed vehicle was produced for designing various control algorithms and a "training" system. It was the purpose of this project to develop a virtual reality environment for the training of the autonomous wheelchair controller and the training of electrical power chair drivers.

SUMMARY OF IMPACT

This project is a software system designed to create a virtual reality representation of the real world using real-world data. The system involves "immersion" of the operator and the objects in a new, virtual space in which the virtual operator can interact directly with the virtual object in sensing environmental data.

The system is designed to be used for training people who need to use an electronic wheelchair. It often takes a year or more to obtain a power wheelchair because of delays associated with third-party approval and reimbursement. By utilizing a virtual reality environment system, persons with disabilities could learn to drive the chair before obtaining a real one. This would permit first-time users to be trained to drive in a more efficient and safe manner.

This system is also designed to train an autonomous wheelchair controller. In some situations, people with severe disabilities cannot personally control their power chair and must rely on a family member or

therapist to move the chair from one location to another. In the virtual representation of the training area, the trainer can drive the power chair along a desired path and download the data into the chair's on-board computer. Utilizing this data, at the user's command, the chair can determine its starting point and then move to a desired location under the control of the self-navigating system. The on-board autonomous obstacle-avoidance system keeps the chair moving in the desired direction while avoiding obstacles along the way.

TECHNICAL DESCRIPTION

The interactive components of the training software were programmed in C. The components used for the system included a blueprint of the training area and the wheelchair, including: 1) a three-dimensional rendering of the training area, constructed from an AutoCAD blueprint file; and 2) an accurate model of the wheelchair in the three-dimensional domain. The program was designed to control, with constant velocity, a three-wheeled power chair with variable slip steering from the rear pair of wheels.

Feasibility

With current hardware and software, it is feasible to develop a program to be used to train consumers in the operation of a power chair controller and to train an autonomous wheelchair controller to drive a powered chair along a desired path at the user's command to a desired location, under the control of the self-navigating system.

This technology was determined to be potentially useful in family care, emergency situations, training of first-time wheelchair users, and the training of autonomous power chair controllers. The application is both practical and cost effective. With appropriate graphical user interface, the program will be easily accepted by users.

Costs of the program for software and hardware include the following:

ITEM	QUANTITY	TOTAL COST
IRIS's Fomers V1.2	1	\$1,200
Programmer's Manual	1	\$200
TOTAL COST		\$1,400

Autonomous Wheelchair Cameras and Mounts

Designer: David Koch

Client Coordinators: Dr. Marvin Fifield, Dr. Richard Baer, Center for Persons with Disabilities

Supervising Professors: Dr. Robert W. Gunderson

Center for Self-Organizing Intelligent Systems

Department of Electrical and Computer Engineering

Utah State University

Logan, UT 84322

INTRODUCTION

Essential components of an autonomous power chair are cameras mounted for obstacle recognition and detection. Virtual reality training requires visual feedback through cameras that are stable so that clear images are produced. Stability is dependent upon the rigidity and precision of the camera mounts.

SUMMARY OF IMPACT

Visual feedback via CCD cameras is a necessary function of an autonomous power chair system. This feedback serves to allow close range, intermittent autonomous control and obstacle avoidance, virtual-reality training for long-range path following, and virtual presence control. These design requirements are derived from the different functions that the power chair should provide. Power chair cameras and mounts are an important addition to the autonomous wheelchair project with the potential of helping numerous people with disabilities learn to appropriately navigate their chairs. The cameras will facilitate remote operator control, thus freeing users from dependency on personal attendants, while adding flexibility of movement within the environment.

TECHNICAL DESCRIPTION

The components of the project are driven by design requirements that include:

(1) Precise linear or rotary adjustment. The cameras are used to create a three-dimensional virtual-presence environment. Thus, they must be adjustable to concurrently focus on objects and provide a three-dimensional image. The cameras need to be at a width proportional to the width of the distance between the user's eyes. So, the cameras must be adjusted each time a new driver uses the chair.

(2) Rigid mounting to facilitate object recognition and detection. The cameras must be stable to create a clear

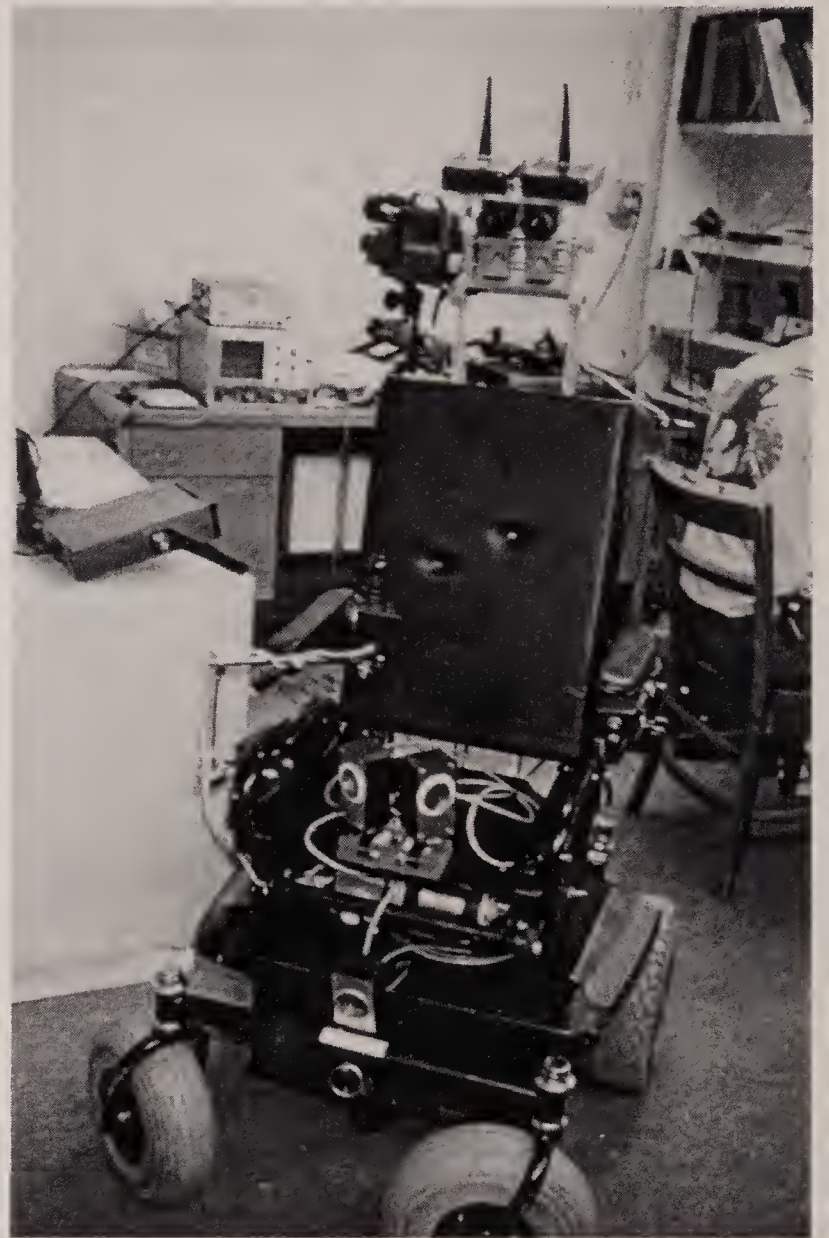


Figure 11.7. Autonomous Wheelchair Cameras and Mounts.

image. Stability is dependent upon the rigidity and precision of the camera mounts.

This project consisted of building mounts and then securing them to the cameras used for the power chair guidance system. It was necessary that the system be flexible enough to accommodate various chair users.

The linear motion of the camera was provided by using pillow blocks mounted on shafts. Two of the shafts were precision Rockwell 60, case-hardened, ½-inch-diameter shafts. The pillow blocks were appropriately drilled; two were fitted with Teflon bushings that ride on the shafts and constrain the motion of the pillow blocks laterally. One other shaft was drilled and threaded, providing the conversion from rotary motion to the shaft of linear motion. The pillow block of the fourth shaft was drilled with an oversized hole that allowed the threaded shaft of the other pillow blocks to pass through. This permitted the pillow blocks to move independently of one another while riding on the same two support shafts. The pillow blocks were machined so that a set of worm gears could be placed in the block that transfers and reduces rotary motion from a screw shaft on the mount to rotary motion of the shaft on which the camera is mounted. The worm gear is supported by bushings and removable locator screws. The complete assembly was then mounted to a frame that was attached to the body of the autonomous wheelchair "test bed" vehicle. A quick-release clamp was used to allow pivotal motion of the entire mount, thus allowing the cameras to be pointed at different angles relative to the horizon.

The cost associated with this system includes the cameras, machining time for the original parts, and the cost of the parts. Components include mounting blocks and frame, pillow blocks, vertical mounting shaft, extension arms, rotary-motion drive shaft, adjustment knobs, and shared connections. The fabrication of these components constitute the bulk of the cost of the mounts. The components that were purchased off the shelf include: cameras, hardened shafting, threaded shafting, bearings, screws, etc., and a quick-release clamp.

Costs associated with the project include:

ITEM	QUANTITY	TOTAL COST
Color cameras	2 @\$850 each	\$1,700
Machine time	20 hrs. @\$30/hr.	\$600
Materials Costs		\$120
Total Cost		\$2,425

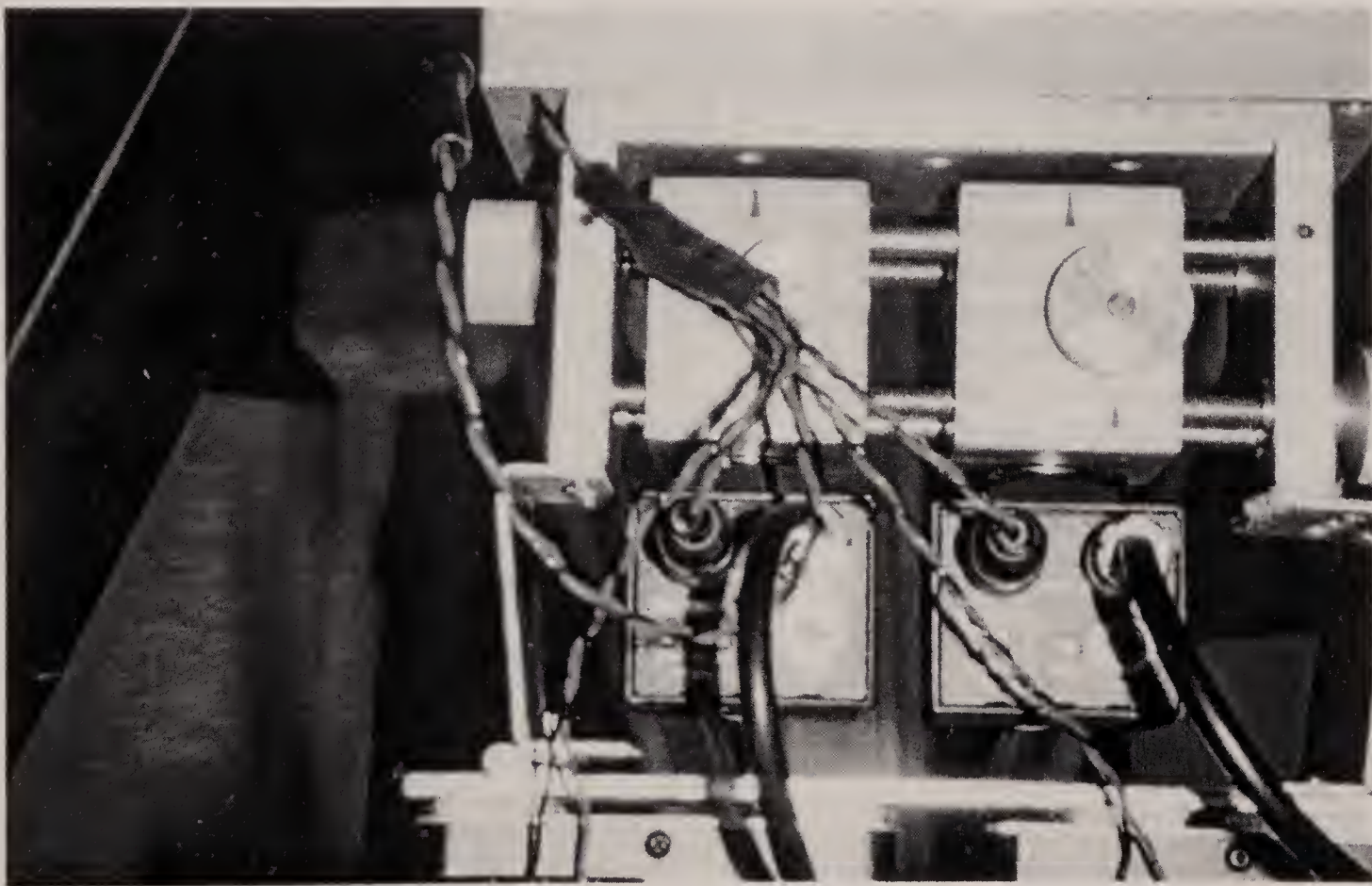


Figure 11.8. Close-Up Photograph of the Autonomous Wheelchair Cameras and Mounts.

Motion Feedback Platform for Virtual Presence Control of the Power Chair

Designer: Don Cripps

Client Coordinators: Dr. Marvin Fifield, Dr. Richard Baer, Center for Persons with Disabilities

Supervising Professors: Dr. Robert W. Gunderson

Center for Self Organizing Intelligent Systems

Department of Electrical and Computer Engineering

Utah State University

Logan, UT 84322

INTRODUCTION

A virtual-presence system that allows a care provider to remotely operate a wheelchair has been developed by the Center for Self-Organizing Intelligent Systems (CSOIS) at Utah State University. However, the current system provides only visual feedback to the remote operator. This information does not always give an accurate indication of the motion orientation of the chair.

It is the purpose of this senior design project to provide motion feedback to the system, allowing the remote operator to feel the same motions of the chair that the occupant is experiencing. Such a system would allow better remote operation and more appropriate and rapid response to chair motion.

SUMMARY OF IMPACT

It was the purpose of this project to collect and provide motion feedback to a remote operator of a power chair, providing additional information on the pitch, yaw, and roll experienced by the occupant of the chair. This information will allow better remote operation by allowing the remote operator to make subtle and rapid changes in the chair's motion, providing a motion platform capable of simulating the range of motion the chair user is experiencing. The remote operator, while sitting on this platform and experiencing the same motion feedback as the user of the chair, can increase the precision and accuracy of the control of the chair.

TECHNICAL DESCRIPTION

A motion platform was built to provide motion in three axes, commonly referred to as pitch, yaw, and roll. The actuators that move the platform in the axis were high-speed linear electronic activators available commercially. Power supply for driving actuators and control electronics for interfacing with the power chair controller were required.

This project used technology and components currently available and in use in a variety of settings. These components were applied to provide motion feedback for virtual presence of a power chair. The project included the integration of these systems, the application of them to a "test bed" vehicle, and a field test of the components to determine their utility in providing necessary motion feedback for a remote power chair operator.

The cost of materials include linear activators at approximately \$1,000, the platform structure at \$200, power supplies at approximately \$500, and interface electronics at approximately \$500. The total cost of materials was approximately \$2,200. Most of the components were available and used by other projects in the CSOIS. The primary costs for this project involved the power supply and interface electronics, the development of the program, and interface electronics between components.

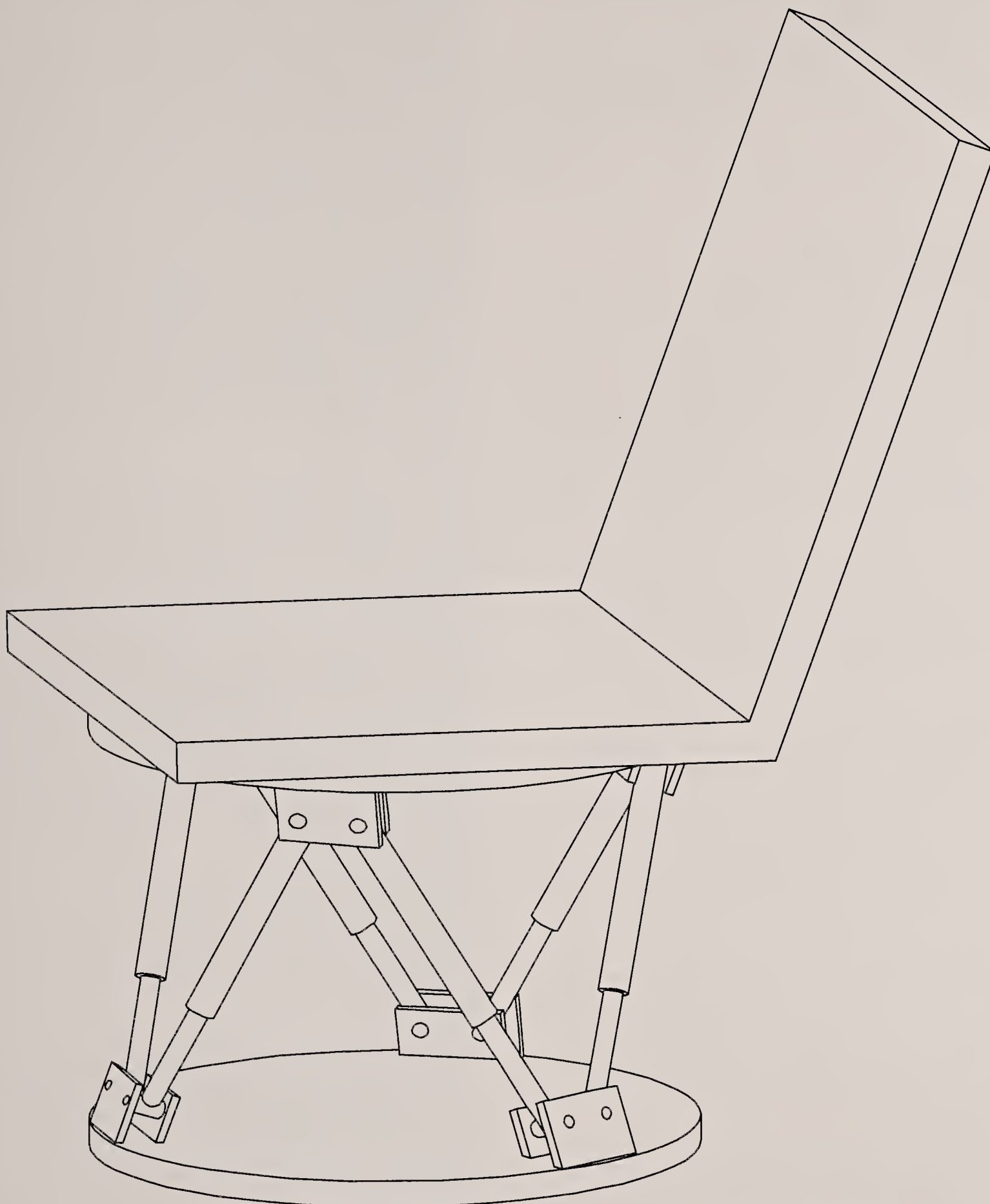


Figure 11.9. Diagram of the Motion Feedback Platform for Virtual Presence Control of the Power Chair.

Forward Motion Prone Scooter Board

Designer: Rick Escobar

Client Coordinators: Amy Henningsen, OT, Center for Persons with Disabilities

Supervising Professors: Dr. Frank Redd,

Department of Mechanical and Aerospace Engineering

Utah State University

Logan, UT 84322

INTRODUCTION

For children with severe disabilities, a prone scooter board is one of the few devices that can expand sensory experience, touch, and movement. Scooter boards are available, but most have to be customized to address the specific needs of clients. Given specific disabilities, combinations of disabilities, ranges of motion, and restrictions in movement, as well as a variety of other factors, many children need a customized scooter board to facilitate movement.

It was the purpose of this project to develop a scooter that would combine several adjustable features, allowing it to be modified to accommodate the needs of a variety of consumers with unique problems.

The client for whom the device was intended is unable to crawl or move on her own. This prevents her from exercising voluntary movement and limits touching and playing with objects. Consequently, interaction and learning from the environment were impaired. The client's leg and thigh movements were rhythmic; thus, with a regular prone scooter board, she moved back and forth, but not forward or backward, for significant distances. As a result, she could not proceed to destinations. To assist her, the project designed a scooter board that allowed only forward motion. Additionally, it was designed to accommodate a feeding tube, a foam pad that could be removed, and a hinged system allowing for height and slant adjustment.

SUMMARY OF IMPACT

Although this project was initiated with a specific child in mind and customized to her individual needs, special features were incorporated to permit it to be adjusted and used by a wide class of individuals with similar levels and types of impairments. The product was designed to be safe, to facilitate interaction with objects and increased sensory functioning, and to al-

low the user to expand touch, movement, and other kinesthetic experiences.

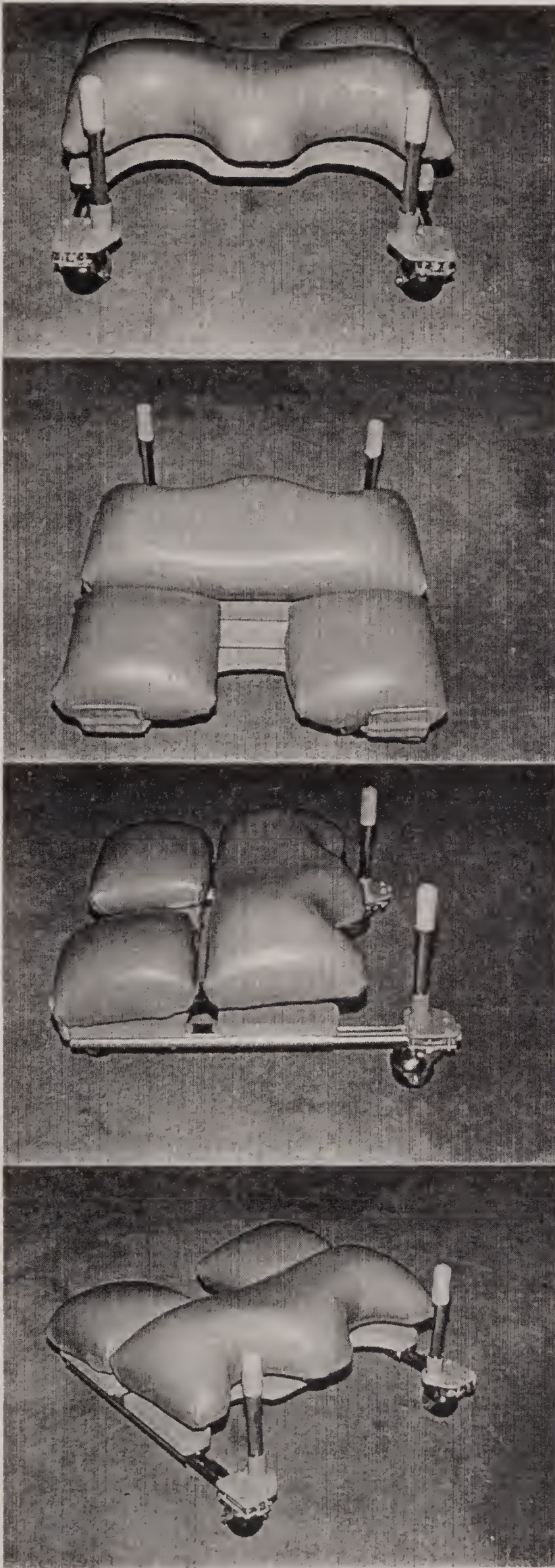
The product represents another step in a line of research to develop a more universal prone scooter board that can be adjusted easily to accommodate the needs of children with multiple and severe disabilities.

TECHNICAL DESCRIPTION

High-density foam material was utilized to give the user adequate body support. The foam padding was separated to accommodate the client's feeding tube. Gliding hand controls were designed into the scooter board with a mechanism that would enable only forward movement. With the use of hand controls, the scooter board facilitates more muscular involvement, enhancing muscular development. The gliding hand controls can easily be locked into place if this feature is not always needed. Features to prevent backward motion were also built near the rear castors of the scooter board.

The design and shape of the board allow the use of free arm and leg movement, and the board is sufficiently wide to prevent tipping either forward or to one side.

The base component is separated from the foam pad, and a hinge is installed to permit adjustment to the board's angle setting. This provides for greater stimulation and greater individual control by the user. Both the lower and upper boards are easily expandable, allowing for quick adjustment for a wide number of children with multiple and severe motor disabilities. Cost of materials is approximately \$75.

*Feasibility*

This design will allow children with muscular problems new opportunities to independently move about, yielding a more normalized environment by providing increased exercise to their muscles and greater opportunity to interact with people and objects.

Figure 11.10. Forward Motion Prone Scooter Board.



CHAPTER 12

WAYNE STATE UNIVERSITY

**College of Engineering
Department of Mechanical Engineering
School of Medicine
Department of Physical Medicine and Rehabilitation
261 Mack Blvd Detroit MI 48201**

Principal Investigator:

*Bertram N. Ezenwa, Ph.D. (313) 993 0649
bertram_nworah@msn.com*

Paper Guide

Designer: Mark E. Hearn

Supervising Professor: Dr. Bertram N. Ezenwa

Departments of Physical Medicine and Rehabilitation and Mechanical Engineering

Wayne State University

Detroit, MI 48201

INTRODUCTION

Confidential documents are normally shredded when the contents are no longer in use. The process involves selecting a single sheet of paper at a time, and guiding it into a paper shredder, which automatically engages the paper for shredding. To enable students with severe disabilities to participate in this type of activity, a paper guide was designed. Upon activation via a switch, a single sheet of paper will be delivered onto a platform and can then be guided down the platform to a shredder by a student with some grasp control. The platform can also be positioned at the proper angle to enable a dispensed sheet of paper to be guided into a shredder, requiring little or no grasp control.

SUMMARY OF IMPACT

The paper guide was designed for students with dis-

abilities. It was intended to help them participate in group projects that require grasp control and other motor skills. The students may work independently or as a group. The first student is 15 years old and has severe developmental disabilities. He has only gross grasp and release capabilities. He cannot pick up one piece of paper at a time. The second student is quadriplegic and has cerebral palsy with severe spasticity. The third student has cerebral palsy and experiences difficulty with grasping. He is a single switch user, and could either grasp a single sheet of paper or slide it along a surface. The fourth student also has cerebral palsy and is confined to a wheelchair. She is a single pillow switch user. Although she cannot manipulate a paper into a shredder, she could participate in a group project by activating a switch. The paper guide was designed to enable the students to participate in a class project involving their dispensing a sin-

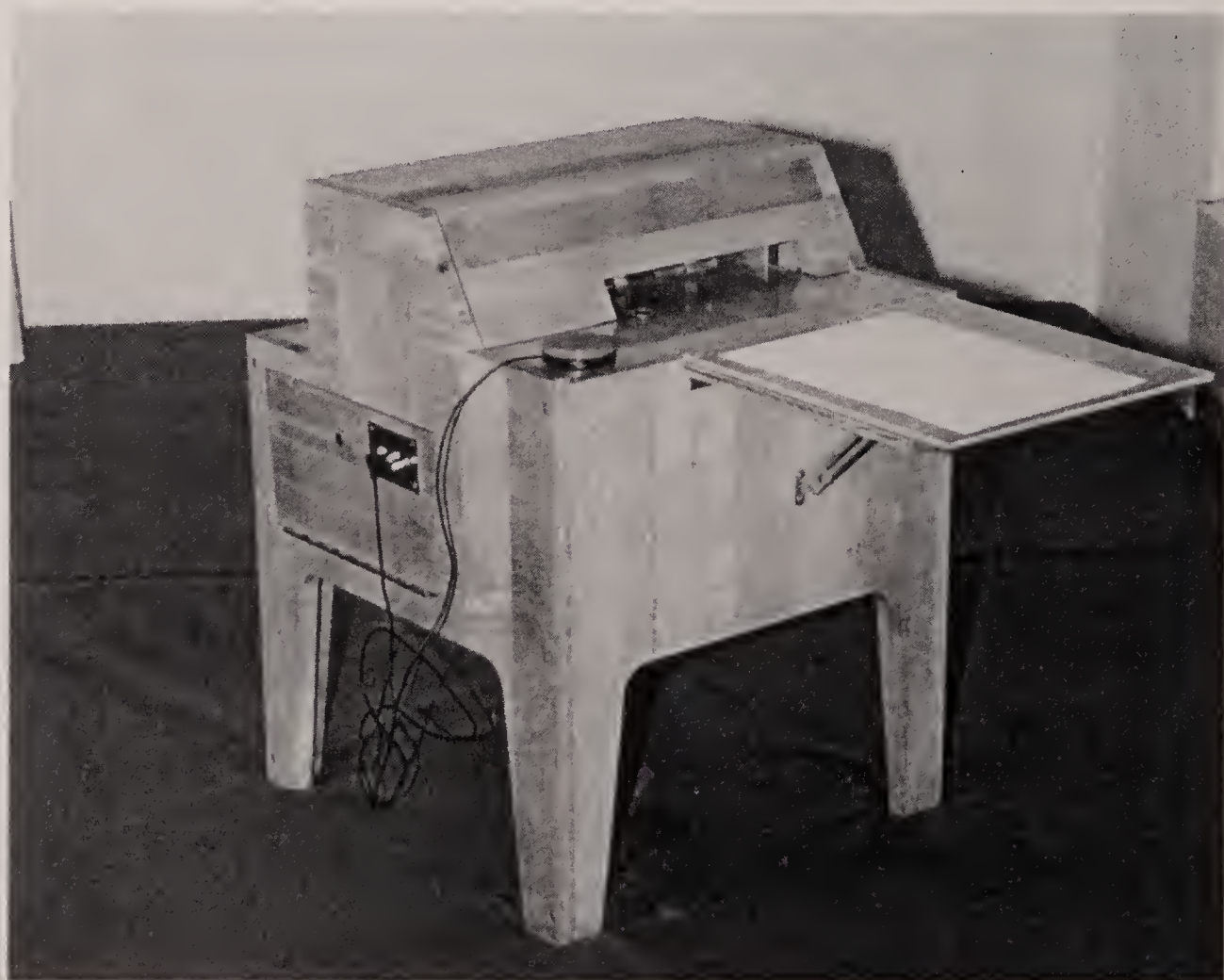


Figure 12.1. Paper Guide.

gle sheet of paper at a time into a paper shredder. The paper guide is shown in Figure 12.1.

TECHNICAL DESCRIPTION

The design consists of a single sheet advance roller. It was designed to articulate with the center of the top, primary drive roller shaft. The vertical position of the single sheet advance pick-up roller is controlled by a push type solenoid, which is activated by the start switch and an infra-red switch. As the advance passes the infra-red switch, the solenoid is deactivated and the spring support shaft returns to the home position approximately .1 inch above the top sheet of paper. Other technical considerations include application of appropriate drive current. The DC Drive Motor and Solenoid require a combined current of 2.6 amps, while the Buddy Button, required due to the

students' disabilities, is rated for 1 amp maximum. To apply the appropriate current ratings, a latch/hold relay circuit was implemented. Instead of using the Buddy Button to start the motor and relay directly, it is used to latch a holding circuit, which operates as follows: When the Buddy Button is depressed, the coil of the third and fourth relays are energized. The third relay supplies a path for the current to the fourth and keeps the coil on the fourth relay energized, holding the switch closed to the DC Gear motor. This is maintained until the infra-red switch is activated and the circuit is unlatched. Figure 12.2 illustrates the transport (rollers) and control (solenoid and infra-red switch) mechanisms. The total cost of this project is \$699.

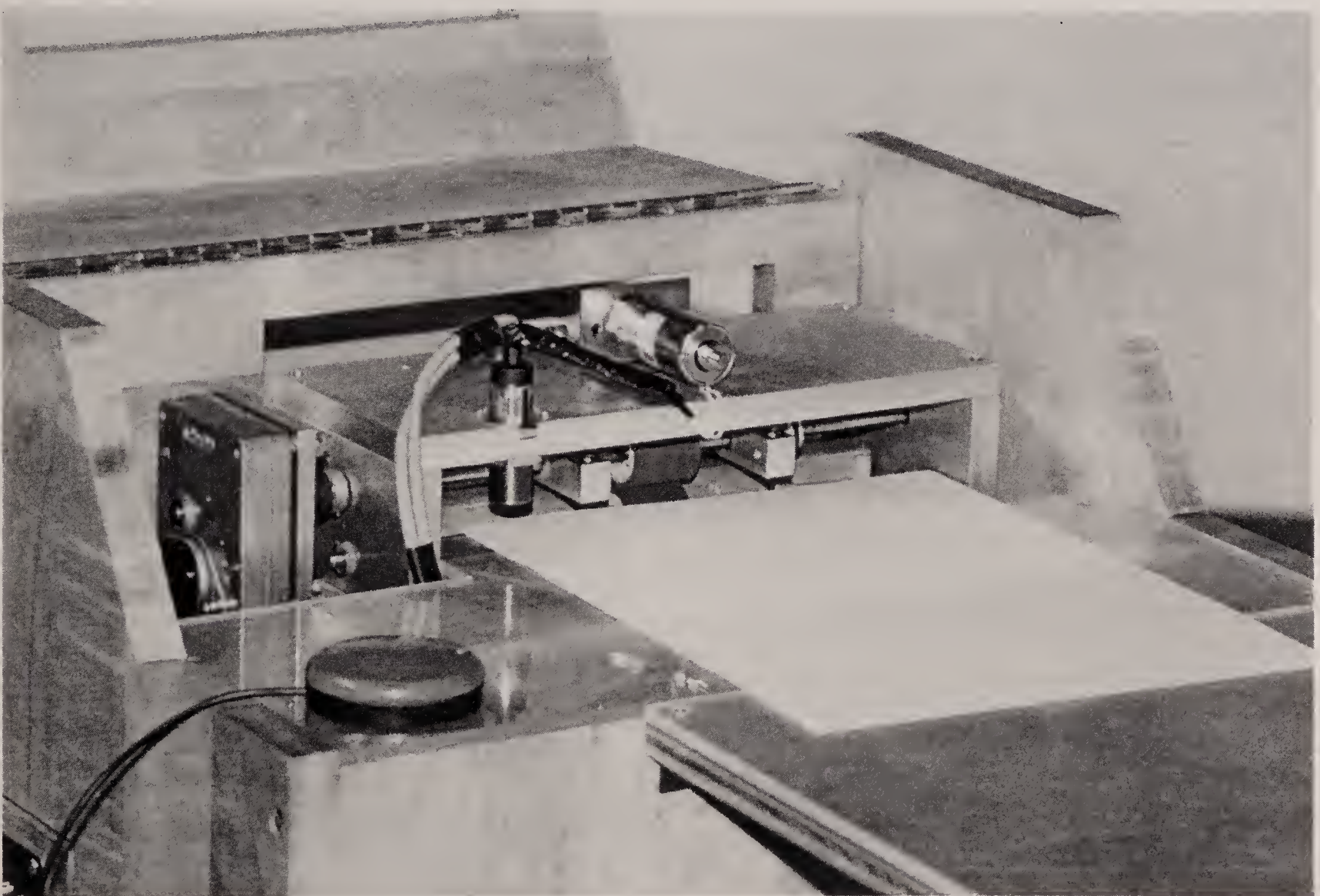


Figure 12.2. Close-Up of the Paper Guide.

Label Position Helper for Students with Cerebral Palsy

Designer: Gang Ye

Supervising Professor: Dr. Bertram N. Ezenwa

Departments of Physical Medicine and Rehabilitation and Mechanical Engineering

Wayne State University

Detroit, MI 48201

INTRODUCTION

Schools, government agencies and businesses often use mass mailings to disseminate information inexpensively. In most cases, the task of placing labels on envelopes is performed by able-bodied individuals. However, this task can also be performed by persons with disabilities, given the means to achieve this goal. Students at the Wayne County Technology Resource Center currently conduct group mass mailing projects, some of which are funded projects by large department stores. Their teacher requested an assistive device to enable correct and consistent positioning of one-sided sticky labels on envelopes.

SUMMARY OF IMPACT

Children who are unable to position labels correctly are sometimes excluded from mailing tasks by their teachers. This system will enable all the students to be

involved in mass mailing projects. In addition to having a positive impact on students' self-esteem, the device may enhance the potential of successful students to obtain employment at agencies that do frequent mailings.

TECHNICAL DESCRIPTION

The design of this assistive device consisted of three components: a mechanical grip, a sliding mechanism, and an electrical staff (solenoid and stop switch). The sliding mechanism is made of wood. The lever arm has an engaged spring under it to push it upward after label application. The lever arm is also on wheels to allow the label dispenser to slide to the place where the label is to be applied. The arm moves towards the dispenser in the medial-lateral axis as shown in Figure 12.3. The total cost of parts for this project was \$62.

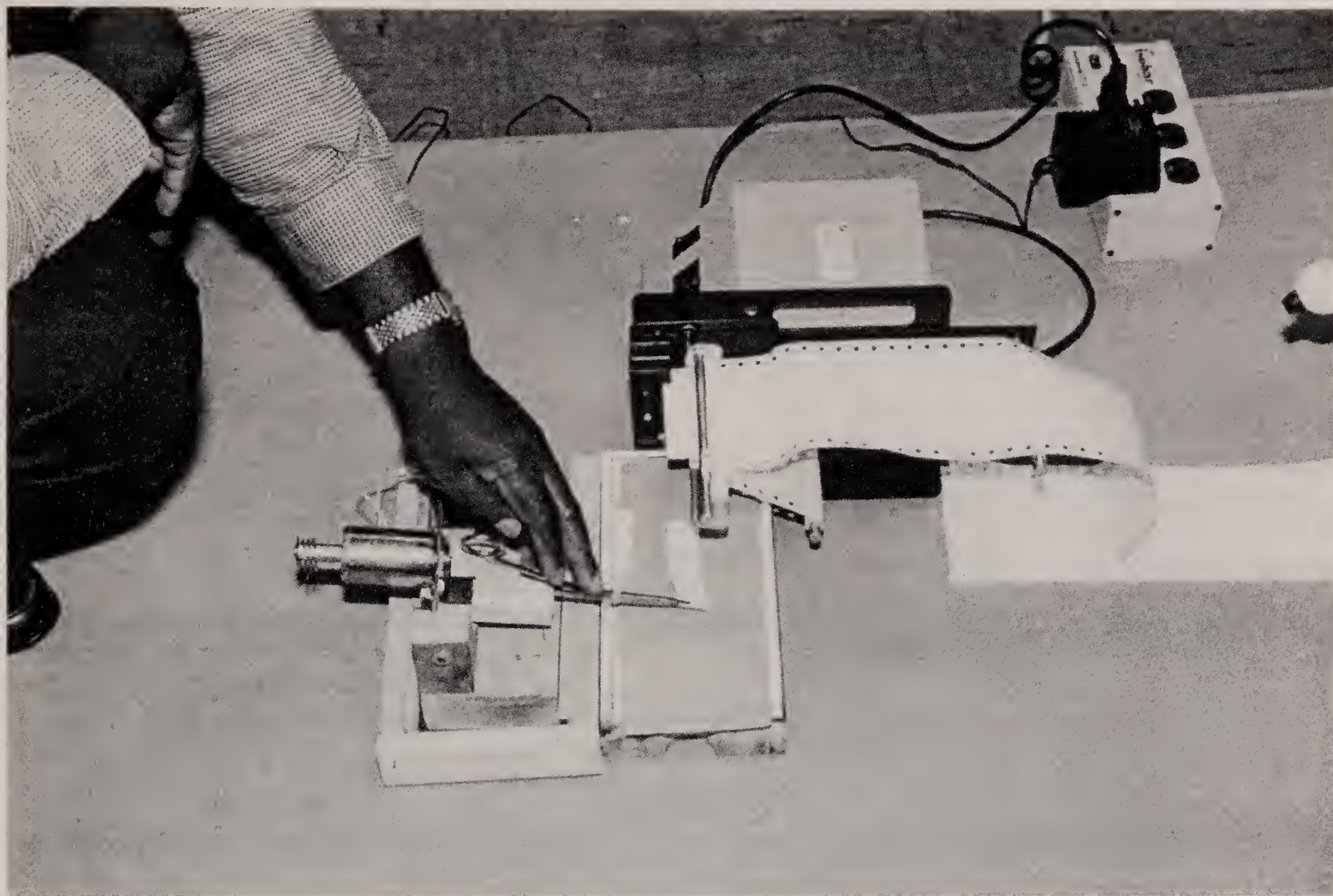


Figure 12.3. Label Position Helper for Students with Cerebral Palsy.

Adjustable Weight Bearing Mobile Walker for a Student with Cerebral Palsy

Designer: Ihab Hanna

Supervising Professor: Dr. Bertram N. Ezenwa

Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering

Wayne State University

Detroit, MI 48201

INTRODUCTION

A teacher requested a walker for a seven-year-old student with cerebral palsy and spasticity. He needed assistance for walking and protections from falling. The child is about three feet ten inches tall and weighs about 38 pounds. System criteria were that it: 1) support him with his entire upper extremity relaxed (no arm support); 2) allow adjustments for weight support, ranging from no support to full support during ambulation; and 3) allow for height adjustment to accommodate the child's growth.

SUMMARY OF IMPACT

Due to his recovery process following a recent hip operation, the child had not been practicing ambulation. He could only bear his weight while standing still and holding his hands on a bar. The design will assist him in beginning to practice weight bearing while walking at school. When fully weight bearing, he may use the system for safe and independent ambulation around the school. The device may also enhance his confidence and reduce the teacher's burden, such that she is more available to help other students.

TECHNICAL DESCRIPTION

The device was designed to allow the child to walk and yet keep him from falling. The structure should be lightweight and yet sturdy enough to support the child's weight. It should be adjustable to accommodate growth, and flexible to support all or some of the child's weight. The design involved modifying and integrating what is already available to achieve the desired performance for the child. It has two major components: the Ambulating Aid and the Support Harness.

Ambulating Aid:

The KAYE Posture Control Walker from KAYE Products Inc. appeared to be the most appropriate for the application. The "B" frame walker illustrated in Fig-

ure 12.4 was chosen since it is expected that the child will often be loading it with his full weight. Swivel front wheels were used to enable frontal ambulation, with the option of being locked, while the back wheels were ratcheted, preventing backward movement. The walker legs can be extended as the child grows. The forearm support is adjustable as the child grows. The Pelvic Stabilizer was used because the child has asymmetrical posture when standing and cannot stay centered. The adjustable lateral pads aid symmetry and control pelvic and trunk alignment. In addition, it will serve as a padded surface to catch the child in the event that he begins to fall while being supported by the harness.

Supporting Harness:

A climbing style harness was chosen to support the child in case of falls. It can be adjusted to support the load fully or partially. However, if it is mounted in the traditional frontal loop (engage and move forward position) it will put too much pressure on the thighs. It was instead mounted in a modified format at the sides of the waist belt. This has a lessened tendency to draw the thighs up and forward and allows free movement of the lower extremities. It was important to ensure that it be practical for the child to get into and out of the walker and harness. This was accomplished by using a locking C-ring and an eye bolt, which enables the child to put on the harness before using the walker. Its only connection with the walker is between the locking C-ring in the harness and the eye bolts in the walker. The total cost of this project is \$550.

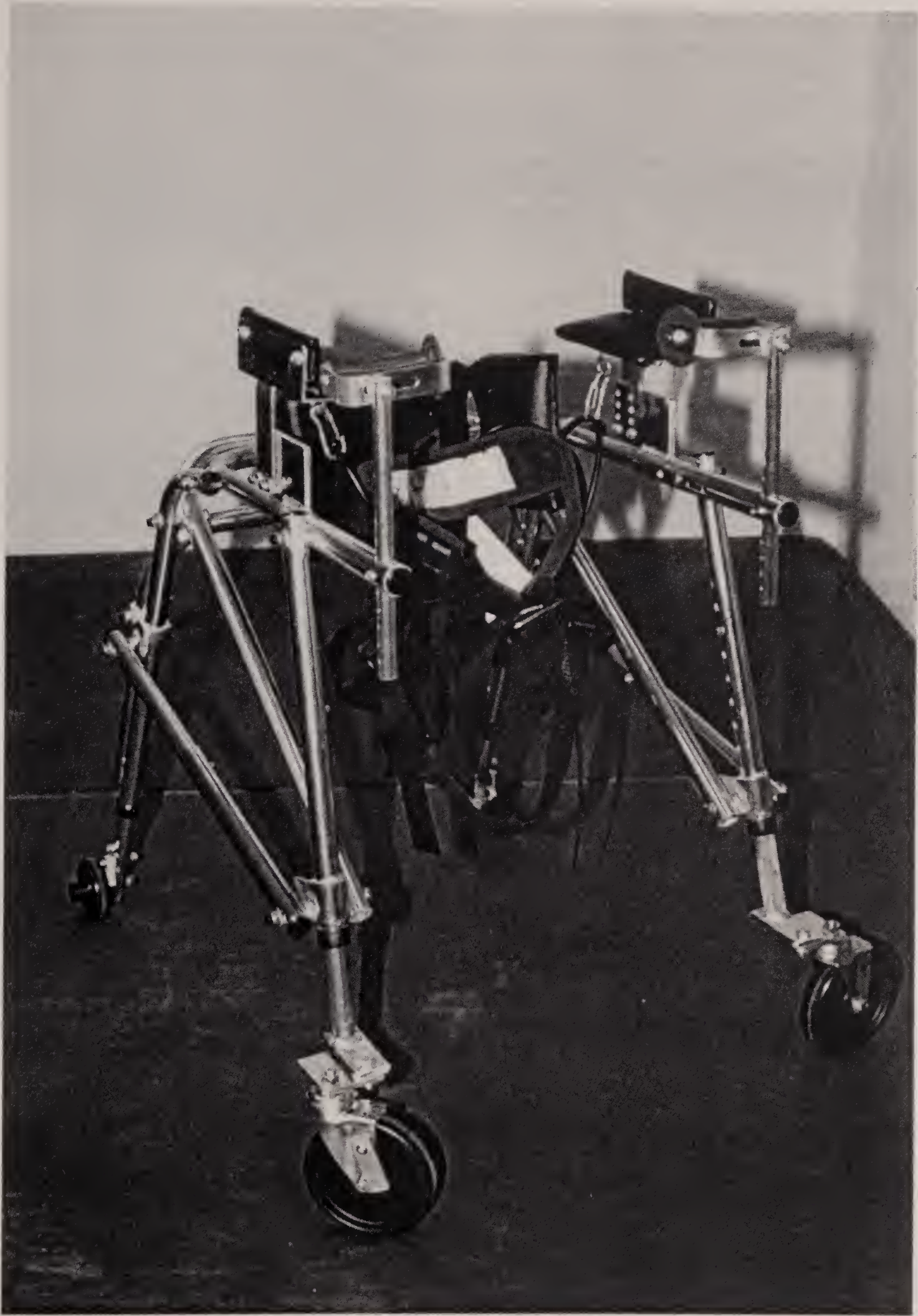


Figure 12.4. Adjustable Weight Bearing Mobile Walker for a Student with Cerebral Palsy.

Evac Chair Adaptation For Horizontal Patient Transport

Designer: Lawrence Kaufman

Supervising Professor: Dr. Bertram N. Ezenwa

*Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering,
Wayne State University
Detroit, MI 48201*

INTRODUCTION

When there is a house fire in a multi-level building, occupants take the stairs to the ground level, and then quickly move to a safe location away from the building. The Evac Chair was developed to enable the evacuation of persons with disabilities down the stairs to the ground level, and for their transport to a safe location.

This chair works very well for transporting persons with disabilities down the stairs. However, it is very difficult to use for transporting occupants to a safe location on a horizontal plane. Figure 12.5 shows the use of Evac Chair without adaptation. Figure 12.6 shows the use of Evac Chair with adaptation to facilitate easy transport of occupants across level ground.

SUMMARY OF IMPACT

The adaptation to the EVAC Chair was designed not to affect its performance as a down-the-stair evacuation system, for which it was originally developed. The adaptation offers the user a quick conversion mechanism from its original mode of use to a system for easy transportation of occupants across level ground. Figure 12.7 shows the impact of the use of the system with and without adaptation on the right bicep muscles. Similar dramatic reduction was seen in the left hand. The adaptation has a definite positive impact on people who use the system to evacuate persons with disabilities from multi-level buildings to safe grounds.

TECHNICAL DESCRIPTION

The first challenge was to design the adaptation so that it would not interfere with the normal operation of the chair, which works very well for transporting occupants down stairs. The second was to be able to deploy the adaptation quickly once on level ground. The third was that the adaptation be able to support the distributed weight of the passenger, lessening the



Figure 12.5. Photograph of Evac Chair Adaptation.

burden of the person pushing the chair. Implementation was to enable quick conversion of the device from a two-wheel wheelbarrow-type design (Figure 12.5), to a four-wheel baby carriage type design (Figure 12.6).

Additional Wheels: The two additional wheels, which rotate about a 3/8-inch solid round axle, are supported on either side by 1-inch aluminum square tubing. On the opposite side of the axle and wheels, the tubing attaches through holes in the two square



Figure 12.6. Use of Evac Chair with Adaptation to Facilitate Easy Transport.

tubes to the solid round bar already existing on the chair. The two square tubes also rotate about the existing round bar when they are released. After the

square tubes and wheels are released, they lock vertically into place by means of a half-moon bracket and spring-loaded pushpin plunger. The bracket is screwed onto one of the square tubes and is grooved with a hole at the top for the pushpin to lock into when the bar is vertical. The pushpin ($3/5$ -10 thread standard spring plunger), which is screwed into a support bracket located on the existing aluminum mainframe of the chair, will positively lock the square tubes into place when the push pin locks into the hole in the top of the bracket. This pin will prevent the square tubes from rotating once they are released and provide stability for the chair during movement.

Quick Release: The lever, from a standard bicycle hand break and cable system, is mounted via a hose clamp near the handles so that the person moving the chair can retain a firm grip on the chair when releasing the two wheels. When the lever is activated, the cable, which is attached to the lever and under tension, activates the standard spring plunger ($3/4$ -10 thread) supporting the square tubes.

Locking Mechanism: The latch, which is a $3/4$ -10 thread standard spring plunger, is at rest when the plunger is supporting the square tubes. The plunger, when at rest, locks into a hole on the side of the square aluminum tube, locking the tubes into position. When the lever is activated, the tensioned cable applies a pulling force on the spring plunger, which compresses the internal spring. When this happens, the plunger moves from its position at rest, allowing the square tubes to fall from their supported position. The cost of this project is \$157.

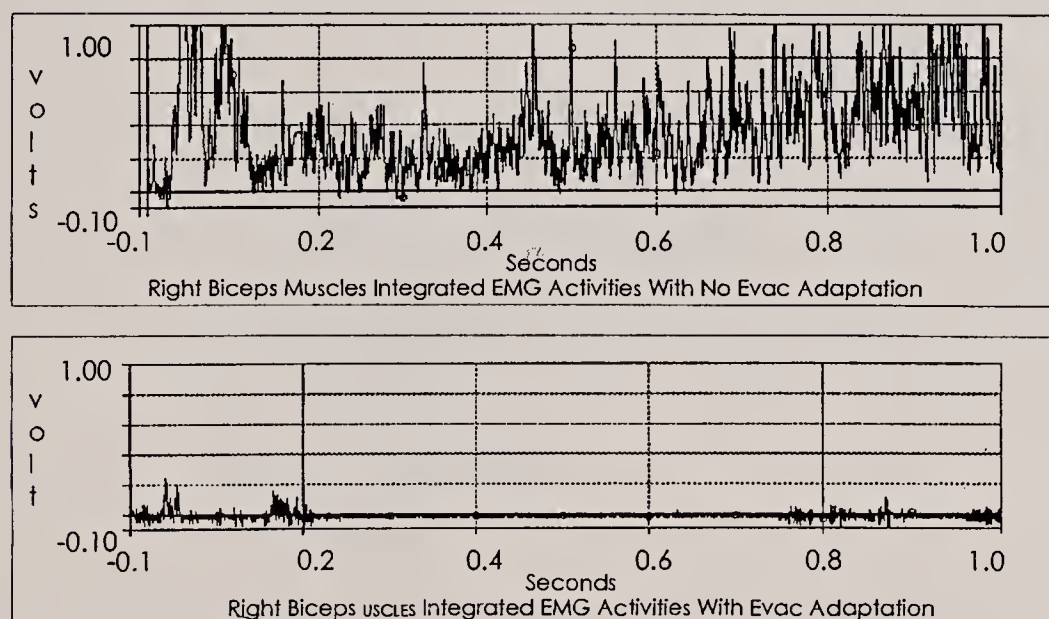


Figure 12.7. Use of the System with and without Adaptation on the Right Biceps Muscles.



CHAPTER 13

WRIGHT STATE UNIVERSITY

**College of Engineering and Computer Science
Department of Biomedical and Human Factors Engineering
Dayton, Ohio 45435-0001**

Principal Investigator:

Chandler A. Phillips (513) 873-5044

Electronic Eye Gaze Trainer

Designers: Michael J. Coyle, Richard H. Eldridge, and Andrew Ku

Client Coordinator: Penny Polyak, Gorman Elementary School

Supervising Professor: Dr. Chandler A. Phillips

Department of Biomedical and Human Factors Engineering

Wright State University

Dayton, Ohio 45435-0001

INTRODUCTION

The Electronic Eye Gaze Trainer is a device used to teach ocular focus and tracking. These skills are necessary to perform more complicated tasks such as reading. The traditional eye gaze training unit is primarily a board upon which several different object or pictures can be mounted. The therapist chooses an object, and then gives verbal and/or nonverbal clues, leading the student to select the object. In this way, the child learns to scan the objects for the appropriate selection, to identify the correct object, and to confirm that he or she has comprehended the therapist's clues.

The shortcomings of previous eye gaze training tools are evident when a student with a speech disorder is using the unit. In some cases, students are unable to use speech to indicate comprehension. Thus, therapists often rely on students' non-verbal communication, such as smiling, to serve as a response indicator. However, neuromuscular problems associated with cerebral palsy initially prevented a particular child from focusing on and tracking objects, and also made it difficult for him to communicate non-verbally. Even reliance on his facial expressions was problematic given the inconsistency of his expressions due to motor control problems. An eye gaze system was developed to enhance his communication ability and to facilitate his oculomotor training.

The Electronic Gaze Trainer (shown in Figure 13.1) is a clear, shatter-resistant board upon which are mounted eight clear plastic pockets. An LED is fixed beneath each one.

There are three user interfaces. The first is a simple toggle button for the student. The main control unit provides options for a teacher or therapist to customize lesson plans, by selecting the number of items to be used, adjusting the speed at which the LEDs will cycle through the items, controlling the brightness of the LEDs, and selecting the mode of feedback. There are three modes of operation. Manual Mode allows

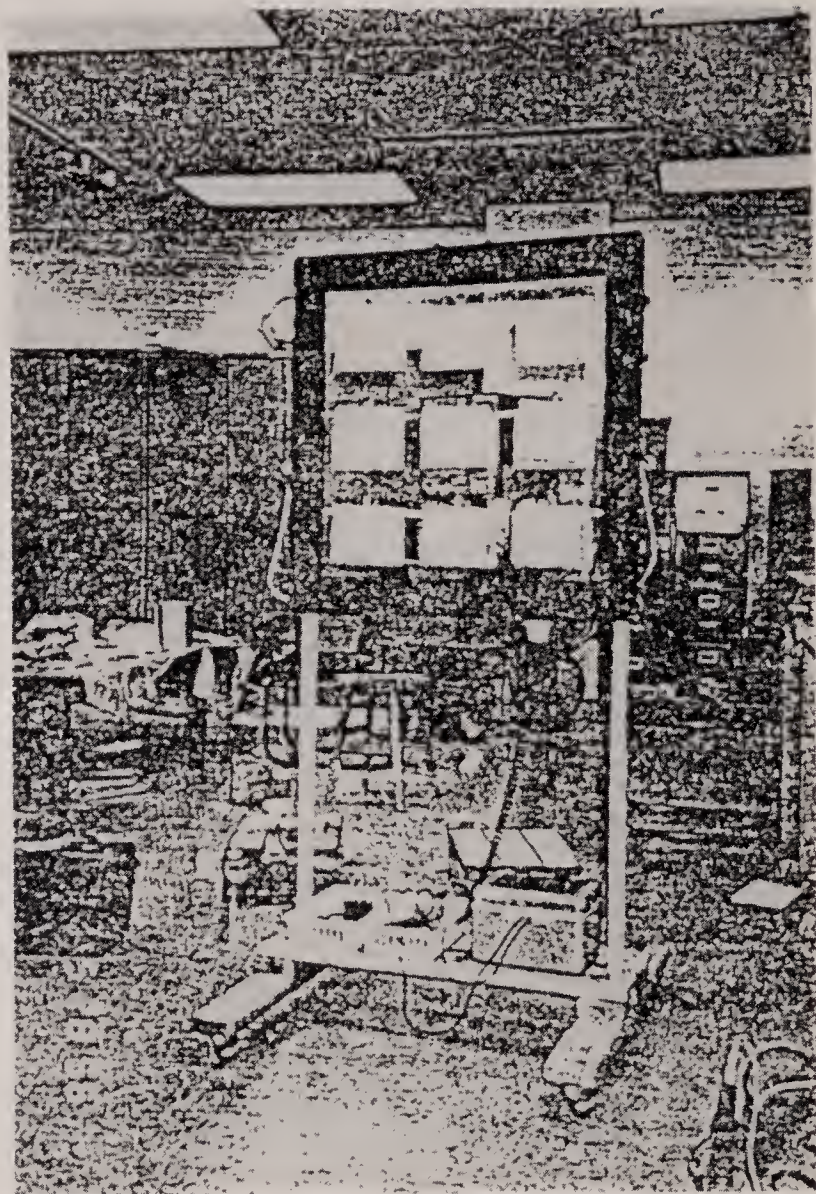


Figure 13.1. Electronic Eye Gazer.

the student to advance the LEDs one at a time across the display board. Hit-Start/Hit-Stop allows the student to initiate automatic LED progression with an initial hit of the student switch, and to stop the LED cycling with a second hit of the student switch. The Hit-Start/Release-Stop Mode operates under the same principle as the Hit-Start/Hit-Stop mode with the exception that the holding down of the student switch starts the LED cycle, and the release of the student switch stops the cycle. The final user input switch is for the teacher. The teacher switch has a toggle switch much like the student switch except that it forces the

LEDs on the display board to do the opposite of what they are currently doing. If the student is in Hit-start/Hit-Stop or Hit-start/Release-Stop mode (i.e., if the LEDs are cycling), and the teacher hits the teacher toggle button, the LEDs will stop cycling. If the student gives a command after this point to stop the cycling, the unit will ignore the command since the LEDs have already stopped cycling. A reset button is provided for cases in which the teacher desires to start the lesson over.

SUMMARY OF IMPACT

The Electronic Gaze Trainer is a very reliable tool for teaching ocular focus and visual tracking. The therapist or teacher now has a consistent method to assess whether or not a student comprehends a lesson. It also allows students to communicate with a teacher by non-verbal means. For example, if one of the plastic pouches contained a picture of a glass of water in it,

the student could advance the LEDs to that particular field and communicate with the teacher that he/she is thirsty.

The design of input controls and the unit itself entailed the elimination of unnecessary distractions to help ensure that the student's attention will be focused on the lesson.

TECHNICAL DESCRIPTION

The Electronic Gaze Trainer board is made of Lexan and has the dimensions of 30 by 30 inches. The actual working surface area where the eight, clear, plastic pockets and LEDs are mounted measures 24 by 24 inches. A black felt border around the board provides an attractive boundary to the unit while at the same time covering the wires that run between the board and the control box.

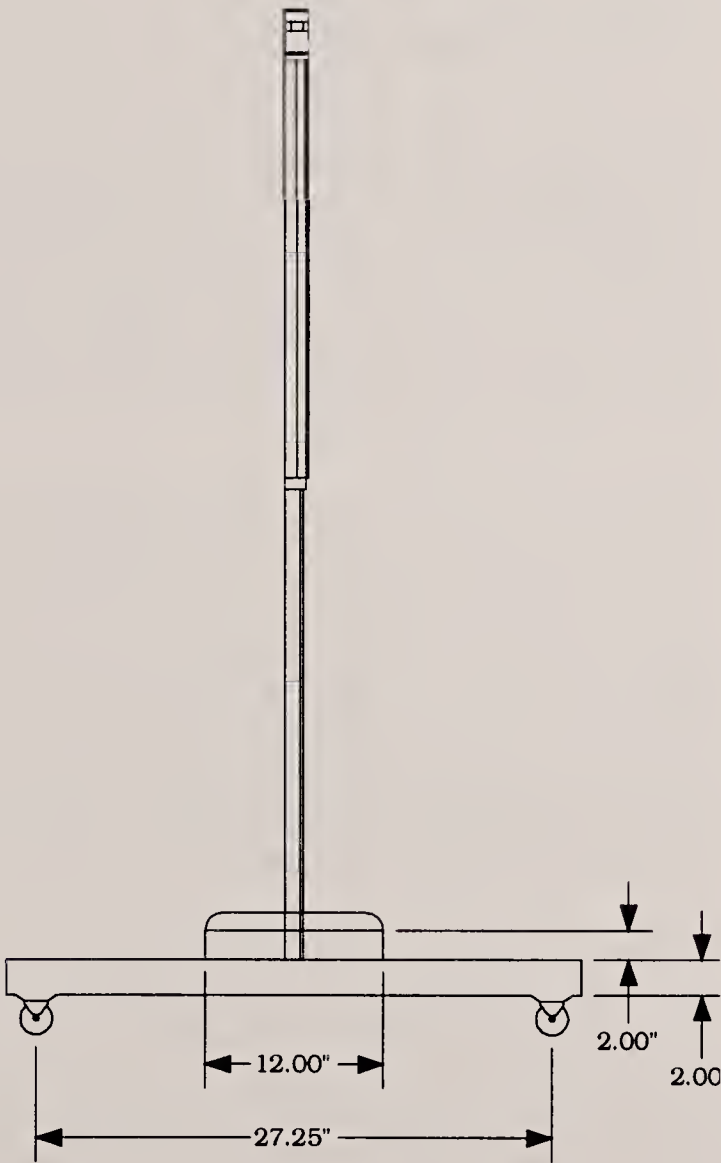
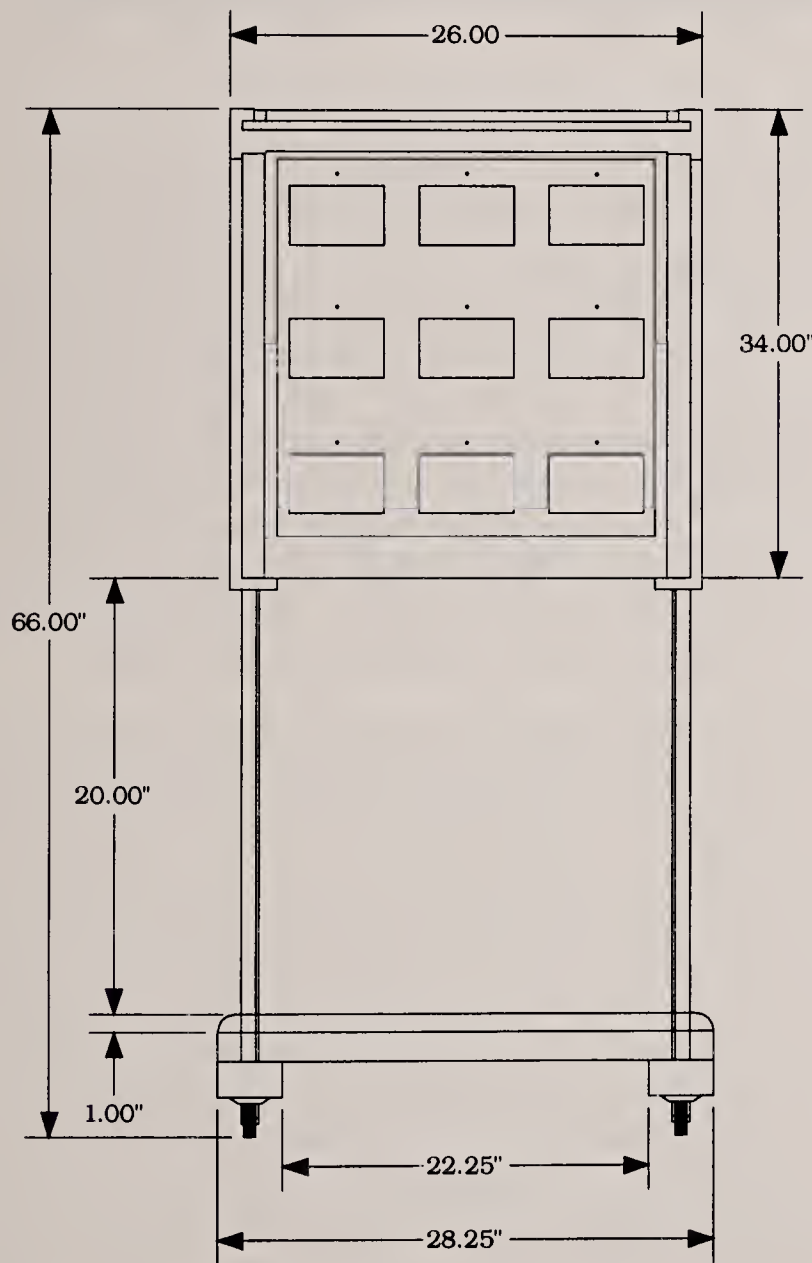


Figure 13.2 Schematic Drawing of the Electronic Eyegaze Trainer.

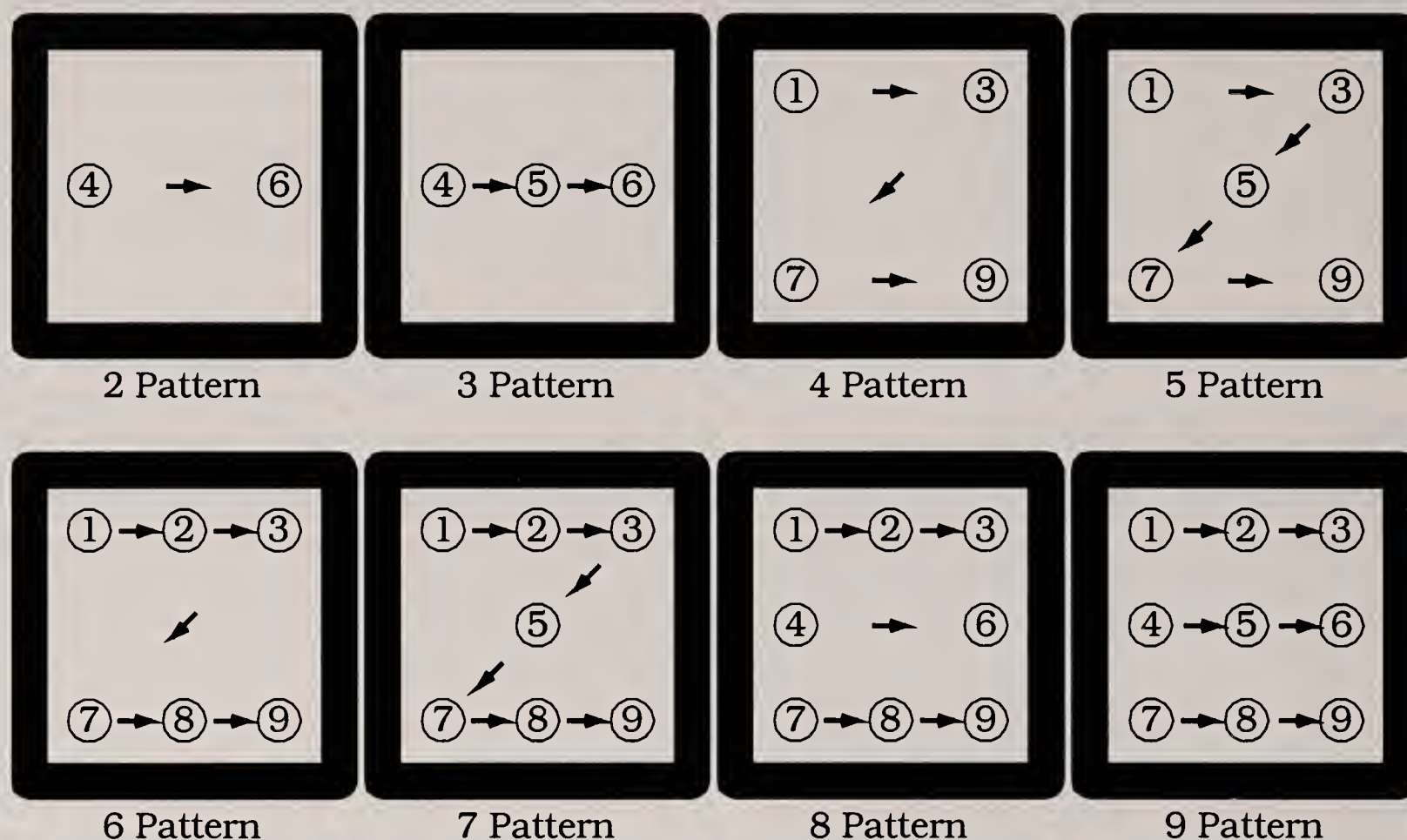


Figure 13.3. Available Patterns

The board is mounted on an adjustable garment rack such that the center of the board can be adjusted from a height of four feet to six and one-half feet. The height of the rack can be adjusted by pulling the lynch pins from the side of the display board's support legs, and raising and lowering the unit according to a marked color coding scheme.

The base of the Electronic Gaze Trainer is composed of two stainless steel legs, two wooden extension legs, a wooden baseboard that lies on top of the extension legs, a wooden crossbar between the two extension legs, four small wooden spacers, and four rubber locking wheels on each end of the extension legs. All wooden parts are coated with polyurethane for a professional appearance and protection from scratching and water damage. (See Figure 13.2 for dimensions.)

In order to operate, the teacher should turn the mode knob, pattern selector knob, speed selector knob, and brightness control dial to the desired positions. Of the three knobs, only the brightness control dial is a smooth turn potentiometer. The speed selector dial sets the time that each LED stays illuminated. These times can vary from one to ten seconds. There are eight patterns available, depending on the number of items to be used. (See Figure 13.3)

The digital hardware of the system is based on the Motorola 68HC11- 811E2 microprocessor. The 'DATA' and 'MAIN' sections of the assembly code set the input/output addresses and subroutine location; they are responsible for the initialization of variables. Once the unit is turned on, the program continually runs and cycles through subroutines that check port E for user inputs. Once user input has been found, the program continues execution. The Electronic Gaze Trainer can run for 50 hours between charges.

The timing for the LED display is handled by an external 555-timer, and the analog-to-digital signal processing is performed by an Instrument-to-Microprocessor-Interface Board (ITMI). The ITMI is a PC board with six primary sections etched onto it, one for each input knob, one for the teacher and student switches, and one to handle the output. The LM555, an oscillating IC configured as an astable multivibrator, handles speed selection by converting the dial-switch input to a one of ten preset resistor values from a resistor bank. Since 555-timer output is low, it is first put through a NPN transistor that acts as a switch between V_{ss} and the microprocessor. The 555-timer output is very close to the lower range of logical high ($0.8 V_{ss}$ to $V_{ss} + 0.1$ volts). The lowest possible logical high would be 4.0 volts. The timer only outputs about

4.3 volts. An additional complication is that the output voltage drops at a steeper rate than V_{ss} itself. In order to account for battery drain, a NPN transistor is used as a switch between V_{ss} and the ITMI board's output. Therefore, the microprocessor always registers 100% V_{ss} as this component's intended logic high.

The microprocessor uses three ports to accommodate the various inputs and outputs required by the design

criteria. Port B is devoted entirely to the LED output while Ports C and E deal with the external clock and user inputs as interfaced with the ITMI (see Figure 13.4).

The total cost of the Electronic Eye Gaze Trainer is \$564.

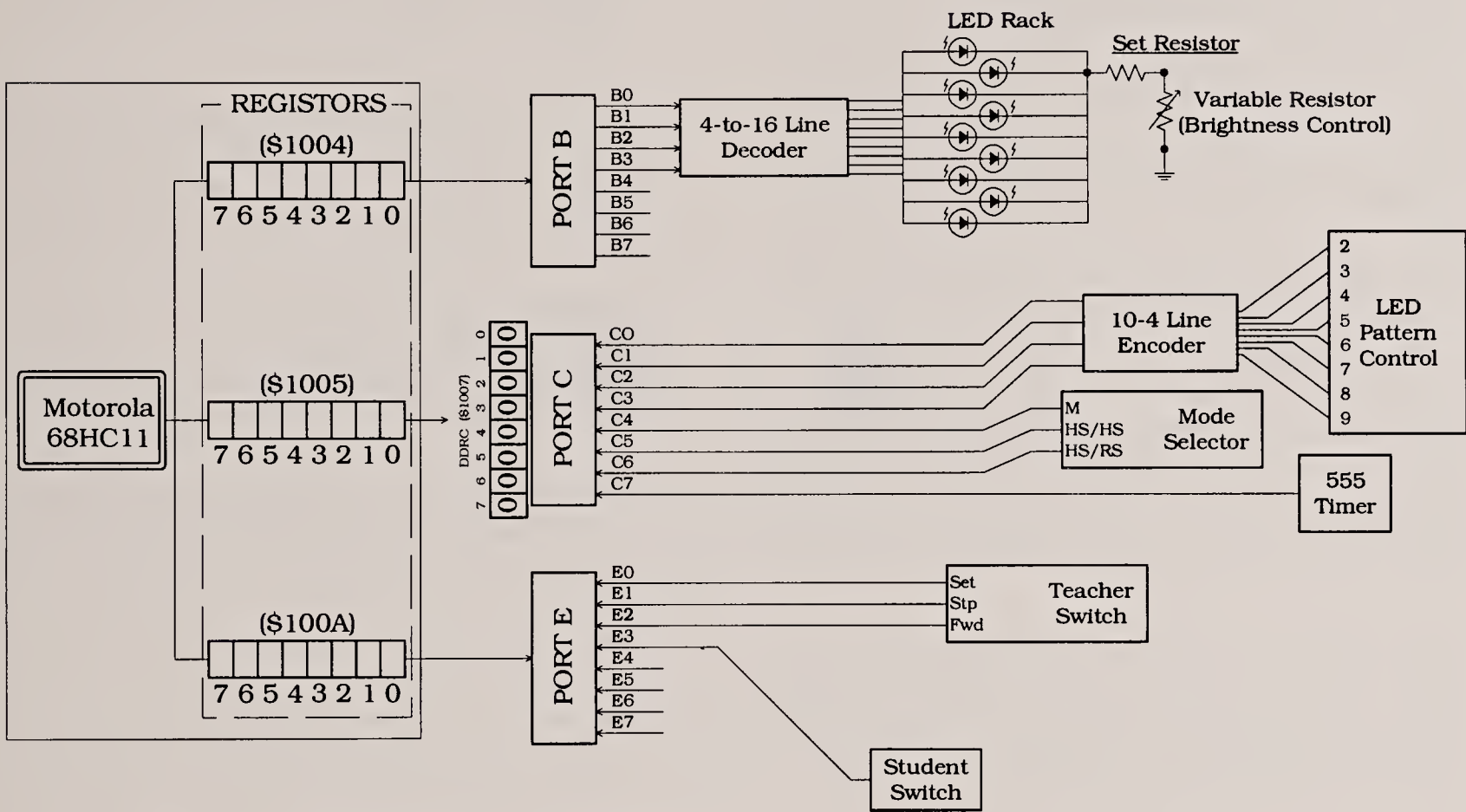


Figure 13.4. Pin Connection for the Motorola Microprocessor.

Dust Mop Lift and Attachment Mechanism for an Electric Wheelchair

Designer: Charles P. Stumpf

Client Coordinator: Terrain Harrison, Meadowdale High School

Supervising Professor: Dr. Reynolds

Department of Biomedical and Human Factors Engineering

Wright State University

Dayton, Ohio 45435-0001

INTRODUCTION

The Dustmop Lift and Attachment Mechanism for an Electric Wheelchair was designed for a student at Meadowdale High School. Part of the education process at Meadowdale involves preparing the students for the work force after graduation from high school. Teachers are helping this client prepare for a janitorial position in which he will sweep hallways and gymnasiums. The teachers at Meadowdale have begun strapping a dustmop onto the front of his wheelchair with bungee cords. The client sweeps the floors by pushing the dust mop up and down the hallway with his electric wheelchair. Because the alignment and position of the dustmop and handle must be constantly monitored, and because another person must raise the dust mop in order to leave the sweepings behind, this method is time consuming for supervising teachers and assistants.

The Dust Mop Lift and Attachment Mechanism for an Electric Wheelchair is easy to install and remove, holds the dustmop in the proper sweeping position, and can be operated independently by the user.

SUMMARY OF IMPACT

The Dustmop Lift and Attachment Mechanism for an Electric Wheelchair met all the design requirements and exceeded the expectations of the project. This product will enable the client to further his vocational skills during his senior year of high school, increasing his independence and potential to graduate with a well-defined skill.

TECHNICAL DESCRIPTION

The moving mechanism responsible for raising and lowering the dust mop is a 12-volt linear actuator affixed to an A-frame attachment mechanism. Two permanent attachment brackets mounted to the cross members beneath the wheelchair provide attachment

points for the A-Frame via allen head screws. The brackets are 0.70 inches deep, allowing the cross member to extend 0.05 inches past the back of the bracket.

The CALA 33-150 actuator from SKF International Corp. comes with a force/direction control card capable of limiting the amount of thrust delivered by the actuator. In this case, the actuator was limited to 20 per cent of its 300-pound linear thrust. The actuator operates in the range from 12.5 to 16.5 inches in the closed position, achieving proper clearance of the wheelchair foot rests while providing the needed range of motion to raise and lower the dustmop.

Because the mop is attached to an adjustable-length extension arm with springs, the dust mop attachment accommodates torsional and vertical forces applied during use. The extension arm is attached to the A-Frame mechanism via a removable pin used as a pivot point. When the mop is on the floor in the sweeping position, the extension arm allows the mop to turn 180 degrees while leaving a three-inch clearance in front of the wheels, thus preventing the mop from being caught beneath the chair.

The electrical controls consist of an operational switch, a force control card, position control switches, and a battery. A two-pole momentary switch with two ON positions allows users with limited motor skills room for error in controlling the device. The adjustable control switches keep the range of motion regulated, which prevents the user from driving the mop into the ground, an action that could cause the wheelchair to tip over. The relays provide current direction control thus determining whether the mop is lowered or raised. (See Figure 13.5).

The safety factor for a head-on collision of the unit with a wall or stationary object, based on a user load of 250-pounds traveling at three feet per second, is six.

The adjustable extension slide on the extension arm will give way well before the actuator can be damaged.

The total cost of the Dustmop Lift and Attachment Mechanism for an Electric Wheelchair is \$1163.

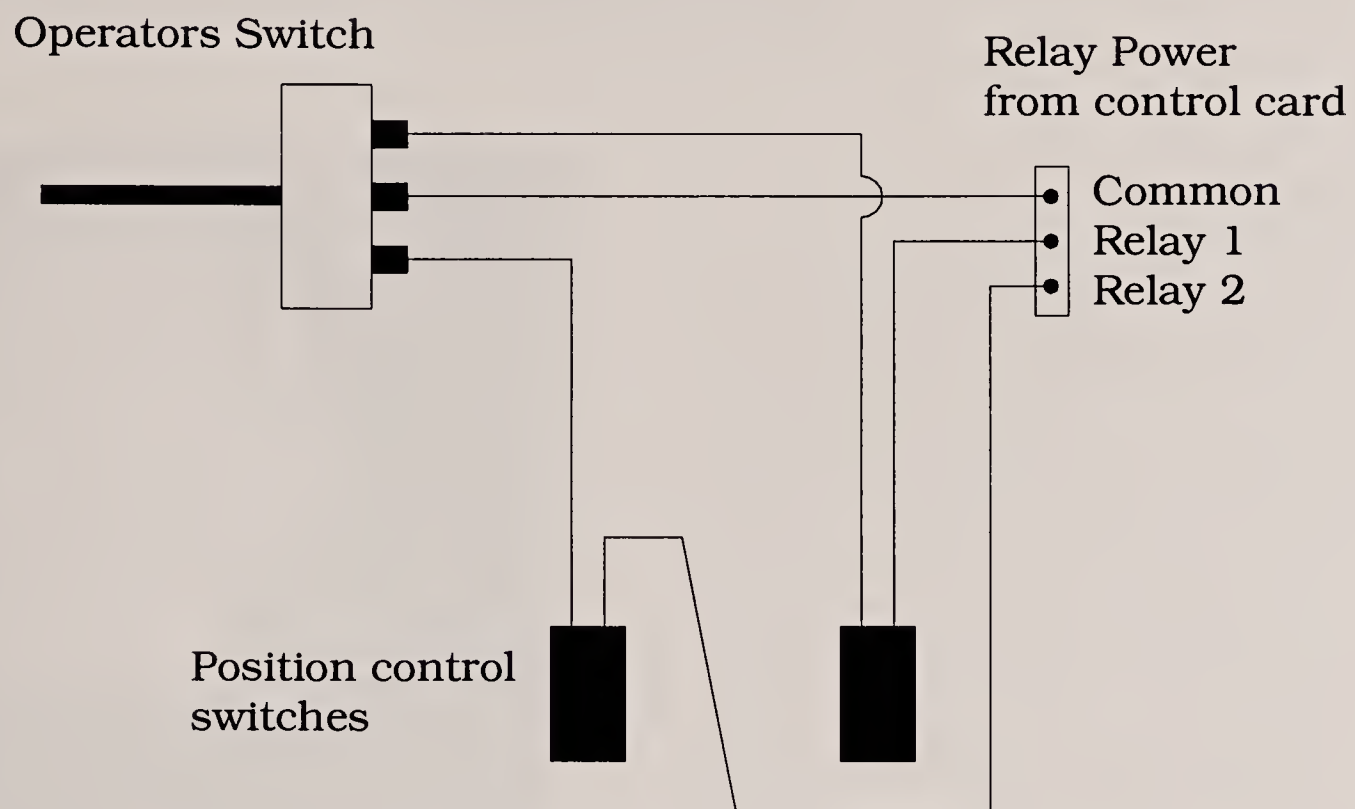


Figure 13.5. Wiring Diagram for Operators Switch and Position Switches.

Upper Extremity Device for a Patient with Brachmann-de Lange's Syndrome

Designers: Dax Pitts, Annette Seger, Sue Seitz, Jason Shearn

Client Coordinator: Debra Vodde

Supervising Professor: Dr. David Reynolds

Department of Biomedical and Human Factors Engineering

Wright State University

Dayton, Ohio 45435-0001

INTRODUCTION

This upper extremity device (see Figure 13.6) is a custom made unit designed to assist a student with Brachmann-de-Lange's syndrome. Brachmann-de-Lange's syndrome involves multiple physical malformations, including small arms with hypoplastic forearms flexed at the elbows, and malformed hands and fingers. This device was designed to enable the client to become more independent. Before the device was created, he used his elbows to perform several functions. His performance was awkward and inaccurate. No other assistive devices of this nature have been developed. Traditionally, complete prosthetics have been used for upper extremity deformities. Unlike prosthetics, the Upper Extremity Device for a Patient with Brachmann-de Lange's Syndrome is an adaptive arm device that allows the user to operate in a familiar manner.

Attachment units were designed for the client's right and left arms. The orthotics is made of Bulk Neoprene and is strapped to the child's arms with Velcro. Three metallic stays are sewed into the device, parallel to the client's forearm, for stability. The stays are enclosed in a pocket of material with a small snap at the top, allowing for easy removal. A harness connects the right and left components. The harness runs in a criss-cross fashion across the client's back and chest. D-rings are used to adjust the straps for stability and tightness.

In order to enable the child to become more independent, attachments (i.e., writing utensils, spoons, cups, and paintbrushes) are covered with Velcro and fastened to the upper extremity device. This allows for easy change of the attachments depending on the needs of the user.

SUMMARY OF IMPACT

The Upper Extremity increases the client's independence by enabling him to perform a variety of tasks



Figure 13.6. Upper Extremity Device for Brachmann-de Lange's Syndrome Patient

such as eating, writing, turning pages of a book, and using a computer keyboard with more accuracy and without additional help from his therapist or teacher.

TECHNICAL DESCRIPTION

The upper extremity environmental interface device is a soft unit designed for comfort and safety. It is made of Velcro loop on one side and neoprene on the other. Attachments can be affixed simply by covering their ends with the opposite-mesh Velcro surface. The sleeves cover the child's arms from his single finger up to his shoulder. The harness and stays are for stability, especially when the sleeves are used to work with heavy objects. The finger area remains open, allowing finger mobility. The elbow area also remains open to allow for sensory input. At the shoulder of the sleeve, a harness is attached with Velcro straps, two in front and two in the back. The straps are criss-crossed in both the front and back and are secured

using D-rings (composed of stainless steel rings and Dacron flaps). Three aluminum stays can be snapped inside pockets on the sleeves for stability. The stays are located on the posterior and lateral side of the humerus and the anterior side on the forearm. All of the stays run parallel to the axis of the bones.

Bulk neoprene is a non-isotropic material, meaning that the orientation of the material determines the

properties. The material is sewed together in a fashion that allows the fibers to run parallel to the applied forces. The large Velcro areas increase the Young's modulus of the composite material and provide a large surface for instrument attachment.

The total cost of the Upper Extremity Device for Brachmann-de Lange's Syndrome Patient is \$680.

Self-Testing Sorting Bins

Designers: Michael Bristow, Teresa Crase, Kristie Johnston, Rachel Beyer

Client Coordinator: Linda M. Comer, Gorman Elementary

Supervising Professor: Dr. Ping He

Department of Biomedical and Human Factors Engineering

Wright State University

Dayton, Ohio 45435-0001

Introduction

The Self-Testing Sorting Bins (see Figure 13.7) enable children to engage independently in a learning activity. Students sort colored disks into corresponding matching colored bins. The sorting activity is used to teach the students to differentiate between items that are "alike" and "different". When a child correctly sorts an item, he or she hears one of four random affirmative teacher voice recordings. Additionally, green lights are illuminated for correct sorting, and a corrective buzzer and red lights are activated for incorrect sorting.

The device eliminates the need for direct guidance and feedback. Prior sorting bins are based on two colors whereas this system works with two or three colors depending on the instructor. One of the major disadvantages of previous methods was the requirement for teacher feedback regarding the student's object placement. Another disadvantage was the use of colored toys that often distracted the student.

Summary of Impact

The Self-Testing Sorting Bins was successfully imple-

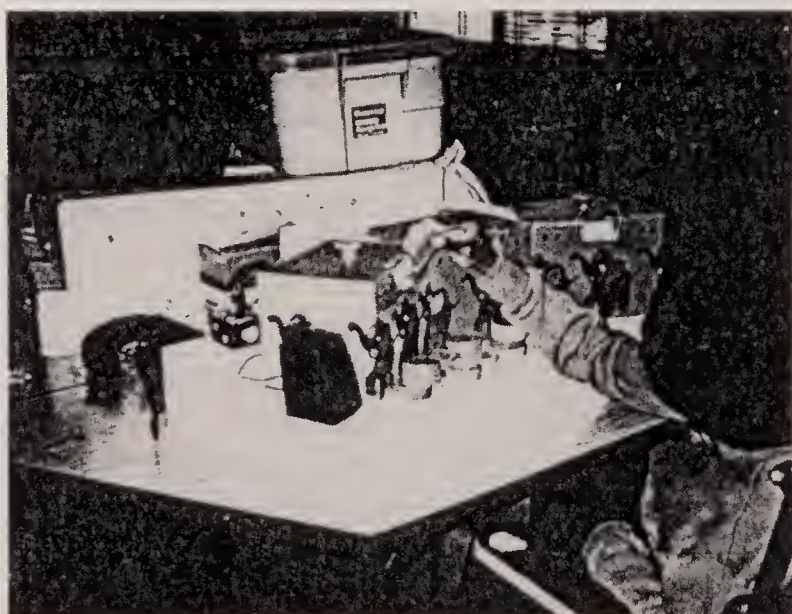


Figure 13.7. Self-Testing Sorting Bins.

mented as a teaching aid in a classroom. The design goals were met in that the Self-Testing Sorting Bins allows students to select disks of different colors, place them in bins of corresponding colors and respond as to whether or not the correct selection was made. Headphones were provided in order to keep the unit from being a distraction to children not using it. Bright lights provide visual stimulation to those that are visually impaired.

Technical Description

The Self-Testing Sorting Bins contains three 6.0 by 8-inch cube boxes of different colors with slots in the front. The bins sit on a four-inch-deep drawer, which catches chips after they have been sorted. The bins are positioned radially to accommodate a child with a 23-inch range of motion (see Figure 13.8). The disks are sorted mechanically based on a very small size differentiation.

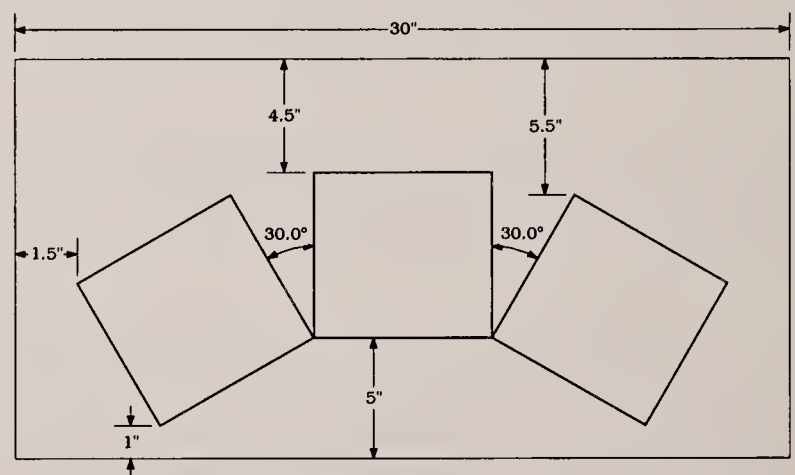


Figure 13.8. Top View of Bin Placement.

All disks are too large to fit in a child's mouth. Disk were made in a series, with each progressively 1/16 of an inch larger in height. The size differences are small enough not to be detected by a child, but sufficient for mechanical differentiation. The disks pass through a series of "bridges." Each time a chip passes a bridge, a switch is closed on the switch circuit (see Figure 13.9) indicating that one of the tests has been successfully

completed by the disk. Of the three switches per bin, only one is wired to positive feedback while the other two are wired to negative feedback.

The feedbacks are connected to a sound chip and the lighting circuit. The sound chip enables the teacher to

record four messages of two seconds each. One of the four messages is played back as positive feedback for the student.

The total cost of the Self-Testing Sorting Bins is \$403.

Each set of resistors is the same configuration:

Left Resistor: 100 Ohms
Middle Resistor: 1k Ohm
Right Resistor: 22 Ohms

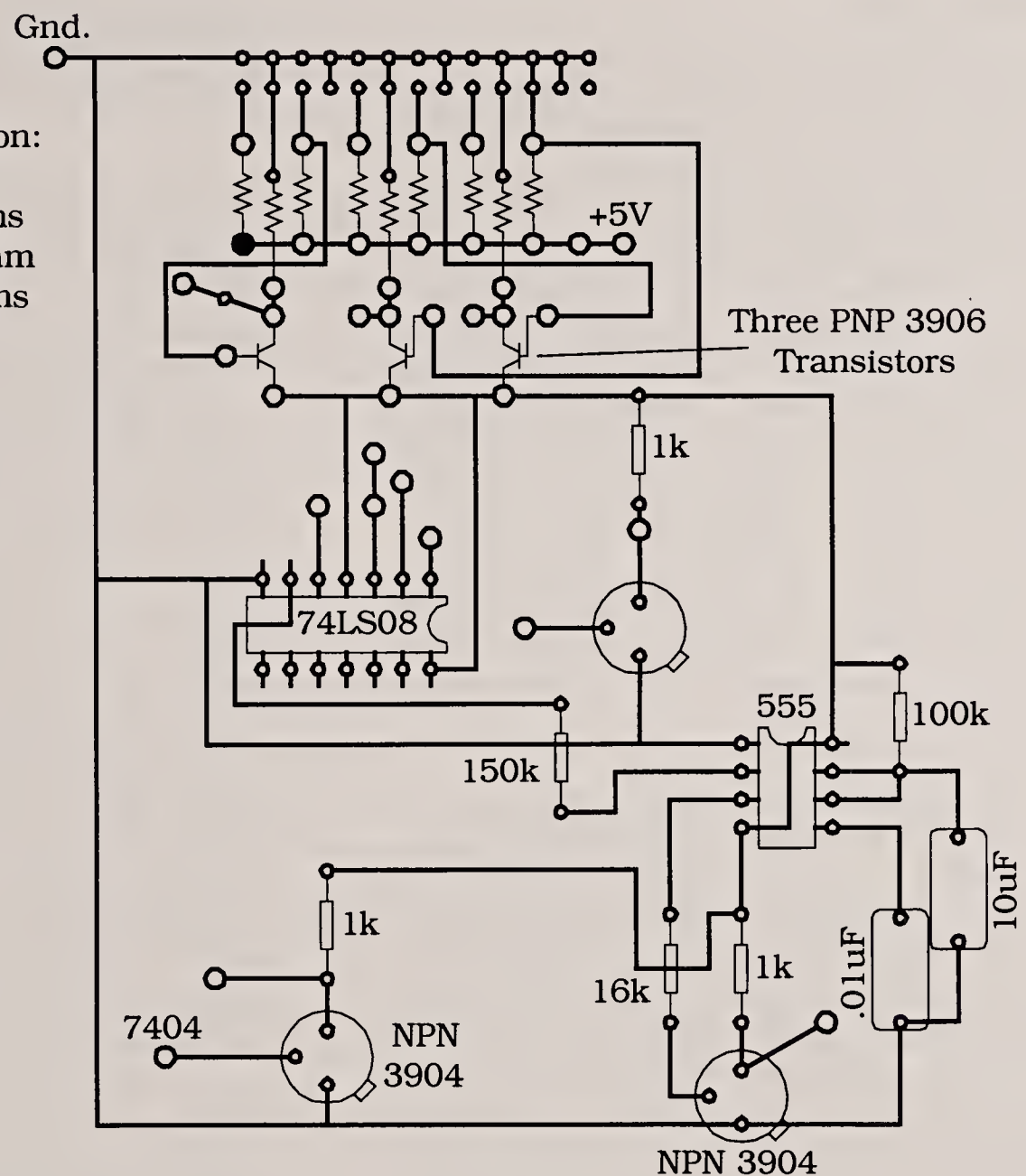


Figure 13.9. Switch Circuit.

Bus Stop Signaling Device: An Example of Audible Signage Technology

Designers: Steve Belcher, Chris Groff, Stephen Tippin

Client Coordinator: Ron Dafler, Miami Valley Regional Transit Authority

Supervising Professor: Dr. Blair Rowley

Department of Biomedical and Human Factors Engineering

Wright State University

Dayton, Ohio 45435-0001

Introduction

The Bus Stop Signaling Device for People with Visual Impairments Project was designed in response to a need communicated by representatives of the Miami Valley Regional Transit Authority (RTA) and its customers. Their aim was to enhance bus stop accessibility and mobility for RTA customers with visual impairments. Currently, people with visual impairments must rely on other people to convey information about buses and bus stop locations, limiting their independence and creating potentially dangerous situations. Existing projects addressing this problem have fallen short in meeting directional/orientation needs, and require a continuous power supply for continuous transmission. They are also too complex for practical purposes and too costly to build and/or install. Further, they do not adjust to ambient volume conditions, and require users to wear headphones or other cumbersome devices.

The Bus Stop Locator enables visually impaired bus riders to locate and identify bus stops through a unit the user carries. The user unit contains two transmitters labeled V (voice) and T (tone). The first transmitter sends out a signal in all directions, which is picked up and decoded by a unit at a bus stop. This bus stop unit then emits an audible sound, thereby allowing the visually impaired person to orient him- or herself and move toward the bus stop. The second user transmitter is for when the visually impaired person has arrived at the bus stop. When the second transmitter is activated, the bus stop unit provides pertinent information audibly, detailing times and routes.

Summary of Impact

The Bus Stop Signaling Device meets the following design requirements: one transmitter unit works with multiple bus stops; radio waves are used for activation; it has a range of 50 feet; it interferes minimally with surrounding radio units; it will hold up under

regional weather conditions; sound output creates a minimal disruption for the public; and on the transmitter unit has easily identifiable buttons for visually impaired users.

Technical Description

The bus stop unit contains a small microphone located at the bottom right rear of the box to detect surrounding sound levels. The microphone current of 0.45 volts peak-to-peak is run through the LM386 op amp (possible gain of 200) into the RMS-to-DC converter, which requires an input of five to 12 volts. This CMOS device calculates the root mean square value of a sinusoidal signal and outputs a pre-determined DC level. This signal enters the SMP04, which holds the voltage, until a trigger signal from the user unit is detected. A 555-timer keeps the trigger to the SMP04 high for the duration of the message (approximately 10 seconds). Keeping the trigger high eliminates the need for feedback. Output of the SMP04 directly controls the level of attenuation on the digital message by a NPN transistor and FET. The transistor acts as a voltage inverter for control of the FET attenuation so as small SMP04 outputs attenuation increases, and decreases as SMP04 output levels increase. The signal enters a 1458 summing amplifier after leaving the SMP04. When the user button is depressed, the signal can be seen at the base of a NPN transistor. When there are +12 volts at the collector of the transistor, the sonalert is sounded. The sonalert draws approximately 70 mA and the maximum current limit of the bilateral switch is 25 mA. A transistor is used to allow the sonalert to draw as much current as necessary. (Figure 13.10) The digital message playback chip (VM1110A) holds a message of ten seconds in length. When the chip is activated, a recorded message is sent to the same transistor network mentioned above.

The bus stop unit uses an AC primary power supply with a battery back-up. If the AC source is working,

the single-pull double-throw relay is switched to enable current to flow from the AC source. If no AC source can be detected, the switch flips to allow the unit to draw current from the battery. The AC source is the standard 120-volt street supply voltage run through a 16-volt transformer, which then passes through a full wave rectifier to make a DC voltage

source. The back-up battery source is a 12-volt, 3Ah gel cell battery, which is recharged through the UC2906 recharging chip.

The cost of the Bus Stop Signaling Device is \$298.

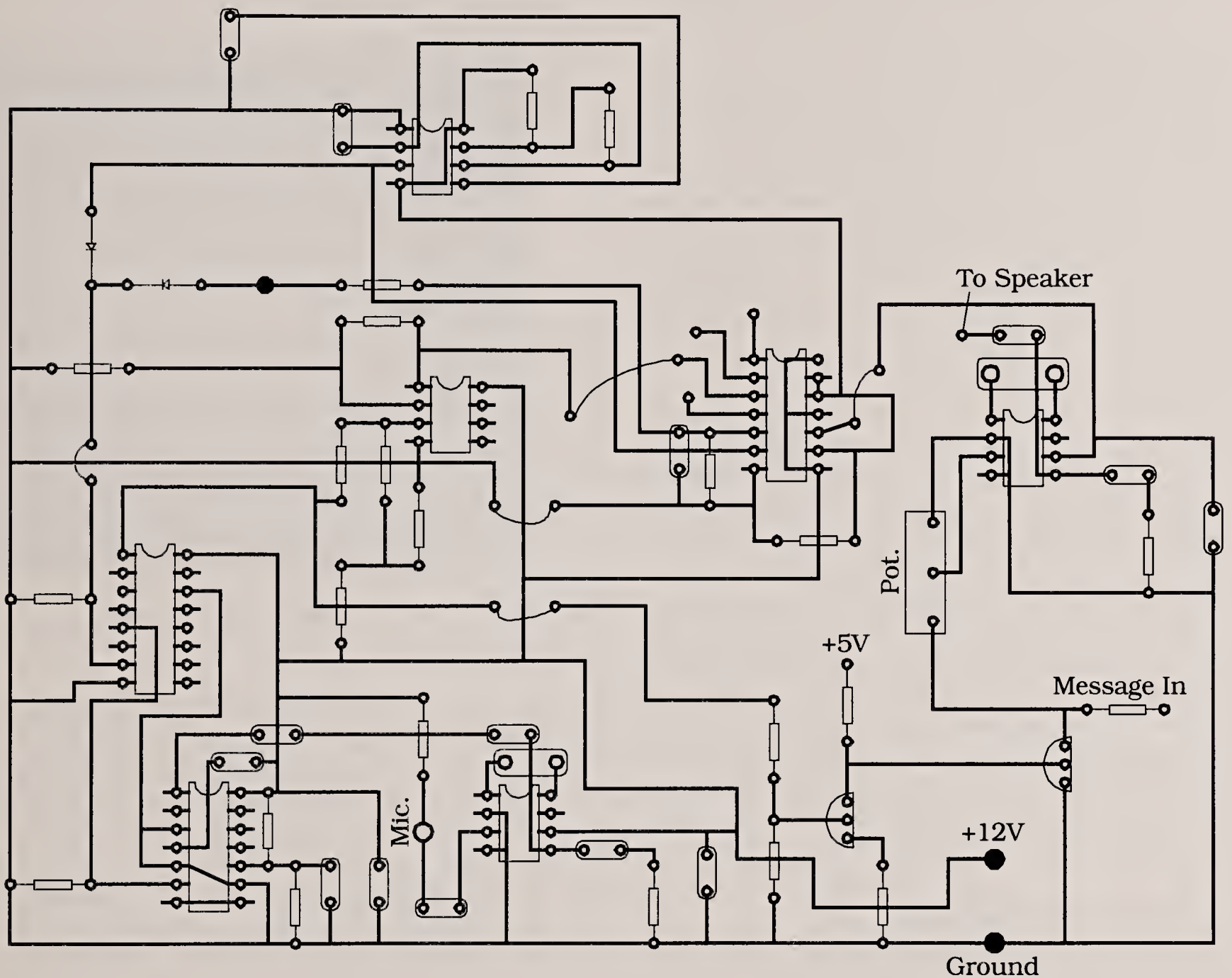


Figure 13.10. Circuit Diagram of Volume Control Circuit.

The Side Kick Environmental Control Unit

Designers: Chris Leigeber, Paul Schaefer, Travis Workman, and Lisa Wurst

Client Coordinator: Dan and Teri Larkin

Supervising Professor: Dr. Blair Rowley

Department of Biomedical and Human Factors Engineering

Wright State University

Dayton, Ohio 45435-0001

Introduction

The Side Kick Environmental Control Unit (see Figure 13.11) remotely controls a television, VCR and five sets of lights in the user's home. The unit is designed for a client with cerebral palsy. This condition impairs his movement, thus making him dependent on others to perform common activities, such as turning on lights, and his television and VCR. The Side Kick provides Nathan greater control over his surroundings, thereby increasing his independence.

The majority of environmental control units are of the basic X-10 unit type, which control appliances via radio signals. The Side Kick is a single unit that has seven controls built in for the user. The seven controls perform 16 functions: turns TV on and off, controls TV volume, changes the TV channel, turns the VCR on and off, stops VCR, plays videotape, fast forwards video, rewinds tapes, pauses tapes, and turns hallway, bedroom, kitchen, family room, and bathroom lights on and off. The keyboard part of the control unit has guards around each key, preventing the client from accidentally pressing a non-desired button as he drags his hand across the keyboard surface. The Side Kick is mounted to the wheelchair tray for stability and accessibility.

Summary of Impact

The Side Kick environmental control unit has been successfully designed to perform all 16 desired functions. The user is able to learn the key functions quickly, and enjoys operating the environmental control unit. The Side Kick has increased the user's independence, allowing him to control things he was unable to control previously.

Technical Description

The Side Kick's keyboard is made out of plastic and has dimensions of 17.0 by 10.5 inches. There are 16 square keys, one key for each function. Two LEDs are located in the upper right corner of the keyboard. The

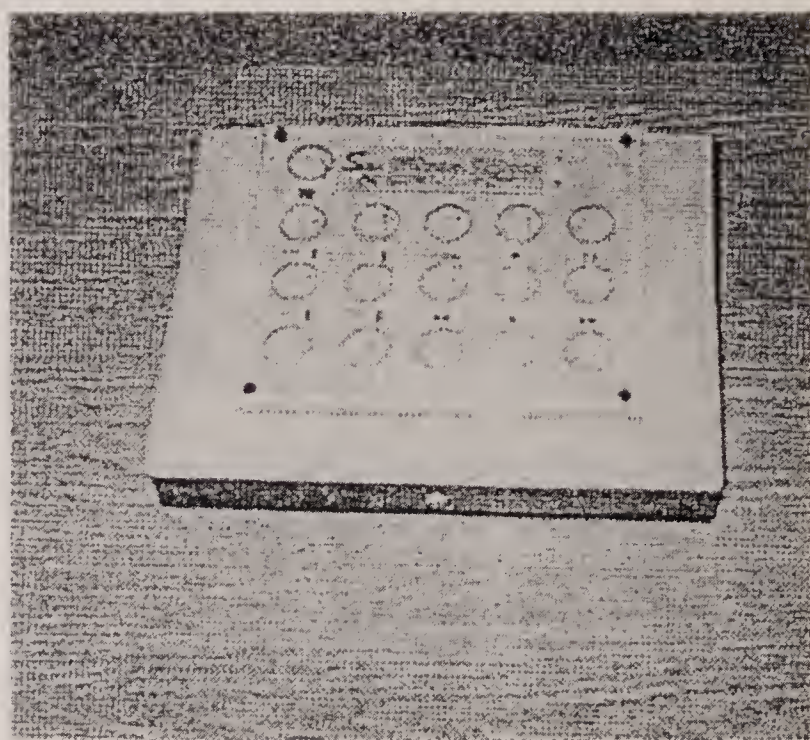


Figure 13.11. The Side Kick Environmental Control Unit.

green LED indicates that power to the Side Kick is ON. The red LED provides user feedback as it flashes when a key is pressed. The keyguard is made out of clear plastic with circular holes. The X-10 transmitter, Emerson remote, Leapfrog infrared receiver/radio frequency transmitter, PCB, and power supply are located inside the keyboard. The five X-10 receivers are attached to the respective lights that they control, and the Leapfrog radio frequency receiver/infrared transmitter is positioned with the infrared beam in "line of sight" of the TV and VCR units.

The lights are controlled by the X-10 transmitters/receivers. When the side kick unit triggers the internal X-10 transmitters, a radio frequency signal that is unique to the receiver is transmitted in all directions, eliminating the need for "line of sight." The X-10 receivers are set with a house code and a unit code allowing each to operate independently of any other unit.

The Side Kick incorporates an Emerson TV/VCR remote to control the respective units. The Leapfrog device, consists of the infrared receiver/radio frequency transmitter housed within the unit and a radio frequency receiver/infrared transmitter located in the TV/VCR's line of sight.

The Basic Stamp II Parallax microprocessor acts as the main control mechanism of the unit. There are 16 I/O pins and an EPROM on the Basic Stamp II microprocessor. RC values are used to determine which key is pressed, thereby enabling 16 inputs and 16 outputs. The program of the microprocessor is in BASIC and continually runs once the unit has been turned on. The microprocessor continually reads RC values to determine which key, if any, has been pressed.

The output from the Basic Stamp II is run through decoders that change the hexadecimal number into a specific signal for the outputting units. The optoisolator switches to the remotes and X-10 units signal when a key has been successfully pressed. The final circuit board layout is shown in Figure 13.2.

A 12-volt 2.3 Ah rechargeable camcorder provides 19.76 days of Side Kick operation when it is left on for three hours per day with a continuous key stroke.

The total cost of the Side Kick Environmental Control unit is \$390.

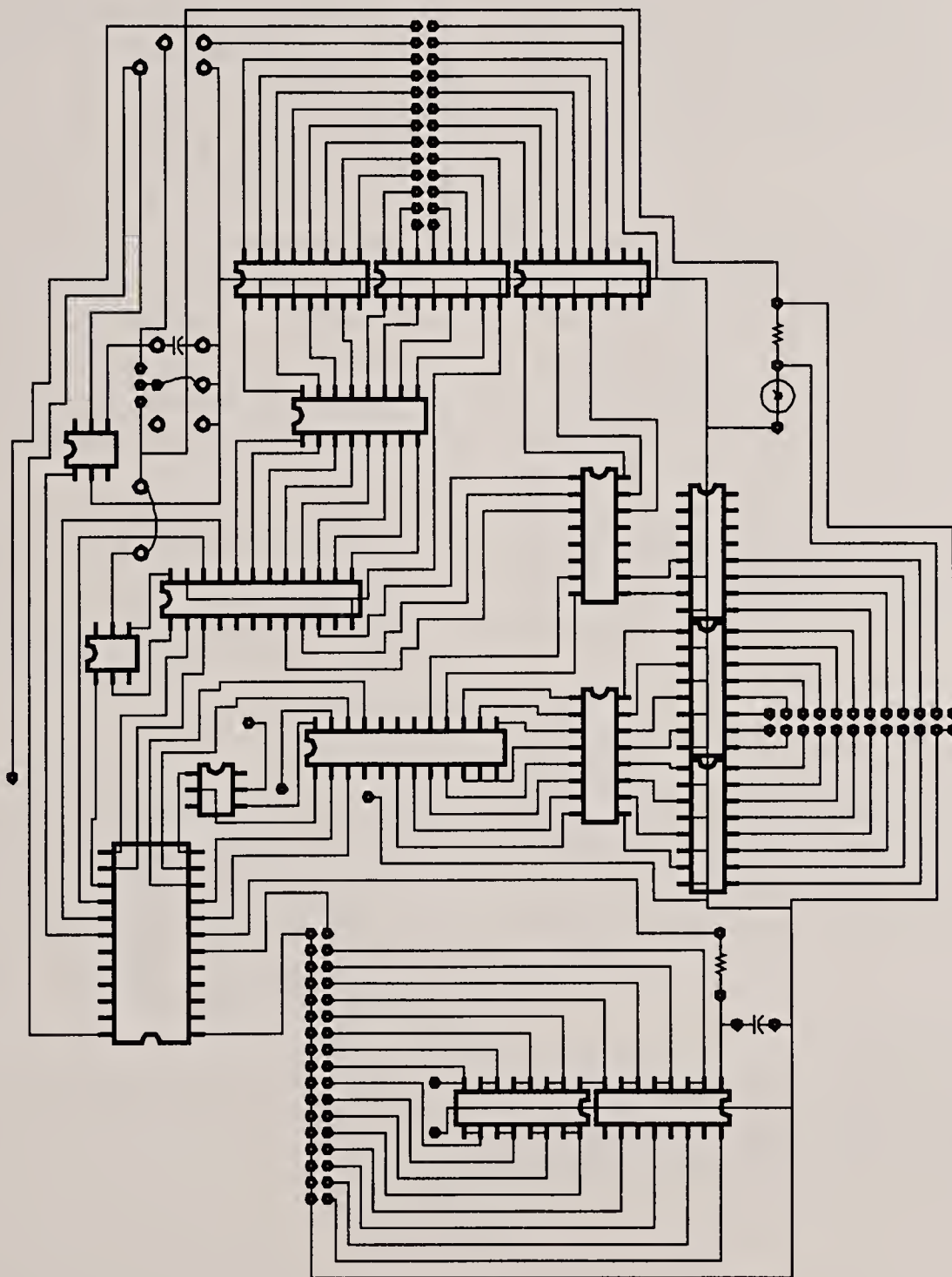


Figure 13.12. Printed Circuit Board Layout of the Environmental Control Unit.

Prosthetic Hand with Electric Motors and Force and Position Sensors

Designers: Joseph Katuin, Angela Slaughter, Donna Jo Therrien, Jeanne Uy

Client Coordinator: Dr. Kuldip Rattan

Supervising Professor: Dr. David Reynolds

Department of Biomedical and Human Factors Engineering

Wright State University

Dayton, Ohio 45435-0001

Introduction

The current project was designed to permit a set of capabilities not available in prosthetic hands currently on the market, that is allowance for: independent movement of each finger; the capacity to "learn" tasks such as writing; safety; a reasonable price; and adaptability to different microprocessors. Prosthetic hands that meet most of these specifications rely on pneumatics to move the fingers, requiring the user to carry compressed air tanks, which may be dangerous.

The Prosthetic Hand with Electric Motors and Force and Position Sensors has three fingers (see Figure 13.13), one of which is opposable, is capable of fine motor skills, contains position and force sensors for feedback, and is interfaced with a microprocessor unit to maximize control and feedback processing. The circuitry has a basic slot-and-card layout with lines going back to the microprocessor parallel port. A/D converters with built-in multiplexing further reduce the complexity of the circuitry. Geared motors that supply sufficient torque to move the weight of the finger component and turn slowly enough to minimize overshoot were selected.

This prosthetic hand is unique in that the fingers contain the motor, such that they do not rely on pulleys and pneumatics remote from the fingers. The motors operate on screw drive system, where a fixed bolt is attached to one end of the joint, while a screw head on a motor runs through the bolt and is attached to the other joint end.

Summary of Impact

The prototype Prosthetic Hand with Electric Motors and Force and Position Sensors yielded valuable data with respect to optimizing finger locations, motor po-

sitions, ranges of sensors, and the hand's ability to neglect input from the computer, which would result in damage to the unit. The prototype is portable and capable of learning and remembering tasks via a microprocessor.

Technical Description

The motor speeds of the Prosthetic Hand with Electric Motors and Sensors are controlled by non-inverting summing amplifiers, which provide positive voltages to the microprocessor. Velocity is measured based on the position sensor input correlated with the internal microprocessor clock. Motor direction is controlled by relays that are capable of turning the motors completely on or off. As mentioned earlier, the torque is delivered by a screw drive motor installation. The motors are oriented to point towards each other, and one motor carriage assembly is used as a finger tip.

The 0.5-inch diameter Interlink Force Sensing Resistors fit well on the tip of the finger and provide a large enough area for a range of objects to be manipulated. The fingers are made of stamped 18-grade stainless steel (0.0478 inches thick), chosen for its tensile strength.

An interface unit controls six motors, three force sensors, and six position sensors in the hand. A bi-directional parallel printer port from a standard IBM-compatible computer exchanges information. This approach is more cost effective and error-proof than the design of a new card to interface the computer with the prosthetic.

The cost of the prototype Prosthetic Hand with Electric Motors and Force and Position Sensors is \$718.

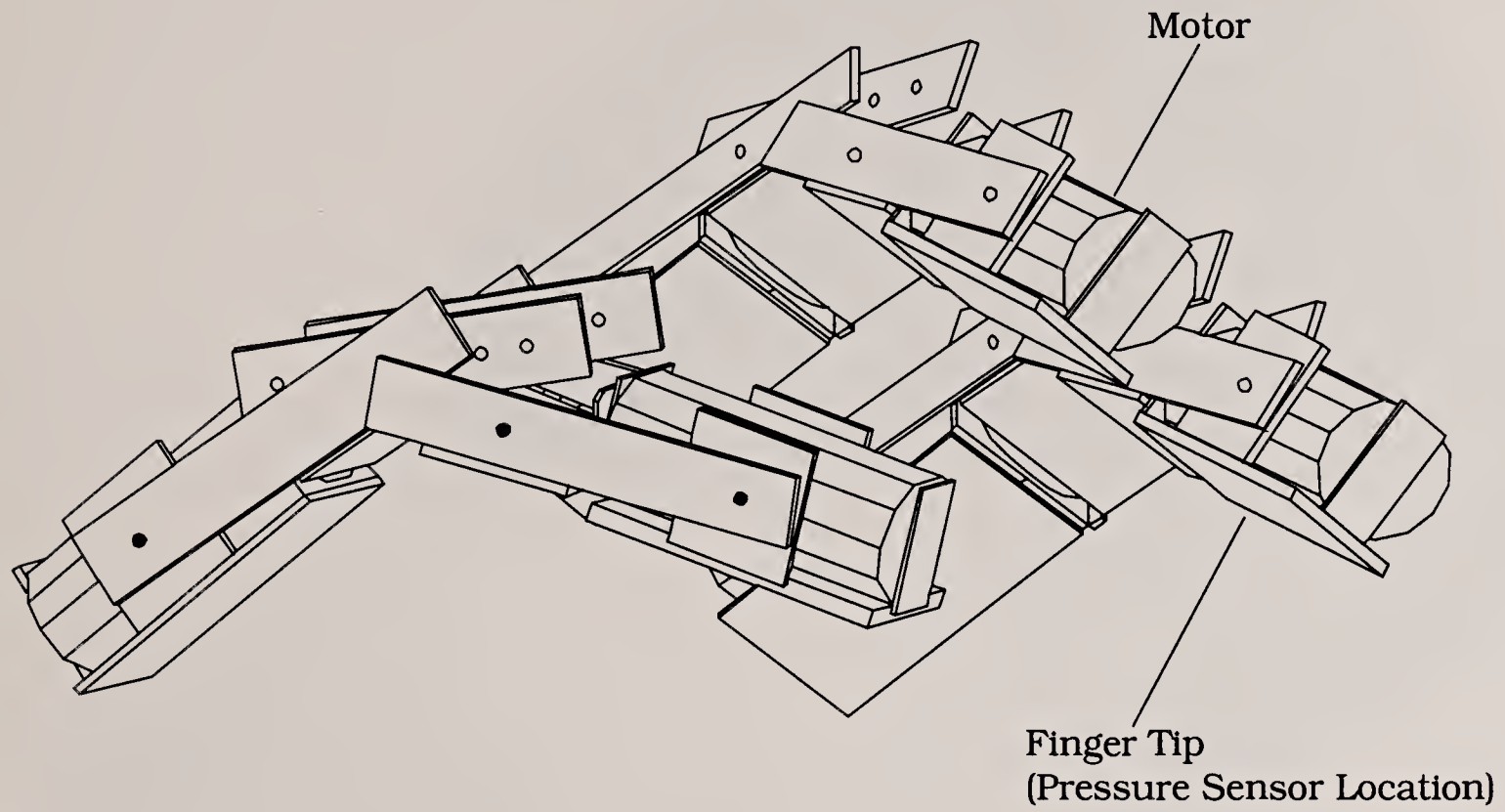


Figure 13.13. Prosthetic Hand with Electric Motors and Force and Position Sensors



CHAPTER 14

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